Marine Fisheries
REVIEW
Vol. 50, No. 2
1988
National Oceanic and Atmospheric Administration • National Marine Fisheries Service

Setnet Fisheries

Marine Fisheries REVIEW

On the cover: A California gillnet vessel. Photograph by Ed Ueber. See his article beginning on page 40.

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U.S. DEPARTMENT OF COMMERCE

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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National Marine Fisheries Service

Editor: W. L. Hobart

The *Marine Fisheries Review* (ISSN 0090-1830) is published quarterly by the Scientific Publications Office, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., Bin C15700, Seattle, WA 98115. Single copies and annual subscriptions are sold by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402: Single copy, $3.75 domestic, $4.69 foreign; annual subscription, $7.00 domestic; $8.75 foreign.

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Hook Timers to Measure the Capture Time of Individual Fish

DAVID A. SOMERTON, BERT S. KIKKAWA, and CHRISTOPHER D. WILSON

Introduction

Gear saturation and interspecific competition for hooks complicate the use of longlines for stock assessment. Gear saturation occurs when fish density is so high the proportion of unoccupied, baited hooks approaches zero before the longline is retrieved. If this occurs, catch is not a continuously increasing function of time, and catch per unit effort (CPUE) is not proportional to abundance (Ricker, 1975). Interspecific competition for hooks occurs when the CPUE of one species is reduced by the catch of other species on the same longline. Such an effect is especially pronounced when the gear approaches saturation (Rothschild, 1967).

These problems led us to search for other ways of using longlines to estimate relative abundance, and from a theoretical standpoint, the most promising alternative was a method based on the time required to hook each fish (Somerton[1]). The abundance estimates used by this method are unaffected by gear saturation because they are completely determined when the last fish is caught. The estimates are also unaffected by interspecific competition, as long as one species does not physically exclude another from taking the hook, because they are computed for all species jointly.

This method requires development of a small, inexpensive timing device that will activate when the hook is struck by a fish. We describe and test two different designs for such a device: A corrosion timer and a digital timer.

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ABSTRACT—*To measure capture time of individual fish on a longline, two types of hook timers installed in the leaders and activated by a striking fish were designed and tested: 1) A corrosion timer that measures time indirectly from the mass loss of the anode in a galvanic corrosional reaction and 2) a digital timer that measures time directly by a digital watch module. The digital timer proved to be superior because it is reusable, quicker to deploy and retrieve, and measures time directly with little error.*

Methods

Corrosion Timer

The corrosion timer is based on the principle that, when two dissimilar metals are connected electrically and placed in seawater, a galvanic cell is created and one of the metals (anode) is ionized. The exposure time to seawater can be estimated from the anode mass loss, which depends on the electromotive potential of the two metals, the size and shape of the anode and cathode, and the salinity and temperature of the seawater (Loose, 1948). For our objectives, the corrosional reaction had to be consistent from one timer to the next and rapid enough so that mass loss in a 15-minute period is sufficient to be easily detectable but not so rapid that the anode corrodes completely in <4-6 hours.

The anode was a 38 mm long × 3.9 mm diameter magnesium welding rod (93.3 percent Mg, 5.5 percent Al, 1.0 percent Zn, 0.2 percent Mn); the cathode was two 25 mm stainless steel (304 grade) fender washers secured by stainless steel nuts to the threaded ends of the welding rod (Fig. 1). To isolate the timers from seawater until the hooks were struck by fish, they were placed in watertight containers (35 mm film cannisters) attached to the leaders (Fig. 2). The rims of the cannister openings were sanded until the caps released with 1 kg of pull, a tension weak enough for the cannisters to be opened by all target species yet strong enough that few opened accidentally as the longlines were set. In addition, the cannisters were filled with a 1:1 mixture of distilled water and isopropyl alcohol to prevent them from collapsing under hydrostatic pressure and thereby changing the activation tension.

Anode mass loss as a function of exposure time was initially estimated in the laboratory. Twenty-four timers were placed simultaneously in seawater (salinity, 34.7‰; temperature, 23.5°C) in a 4,000-liter tank and removed, three at a time, at 15-minute intervals for up to 2 hours. The resulting mass loss was linear with time, and variability among replicates was so low that there was no overlap in mass loss between adjacent 15-minute intervals (Fig. 3). Although additional laboratory calibration experiments were run at approximate in situ temperatures and salinities, we suspected that pressure (the timers were intended to be used at <1,000 m depths),

[1]Somerton, D. A. A method of stock assessment using the time-to-capture of individual fish on a longline and its application to pelagic armorhead, *Pseudopentaceros wheeleri*, on the Hancock seamount. Manuscr. in prep. Honolulu Laboratory, Southwest Fisheries Center, National Marine Fisheries Service, NOAA, 2570 Dole Street, Honolulu, HI 95822-2396.

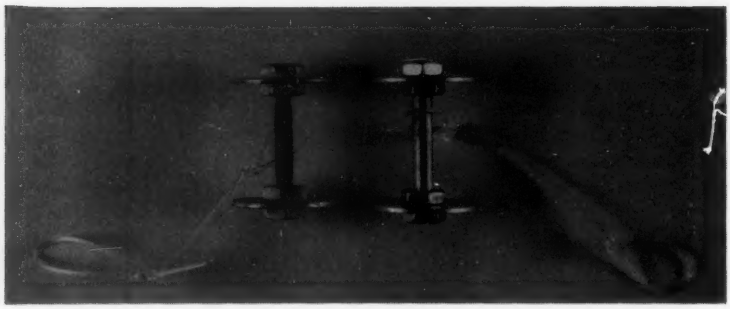

Figure 1.—Corrosion timers before (right) and after (left) exposure to seawater for 2 hours. Note the loss of material from the anode (central rod) and the deposition of material on the cathode (end pieces).

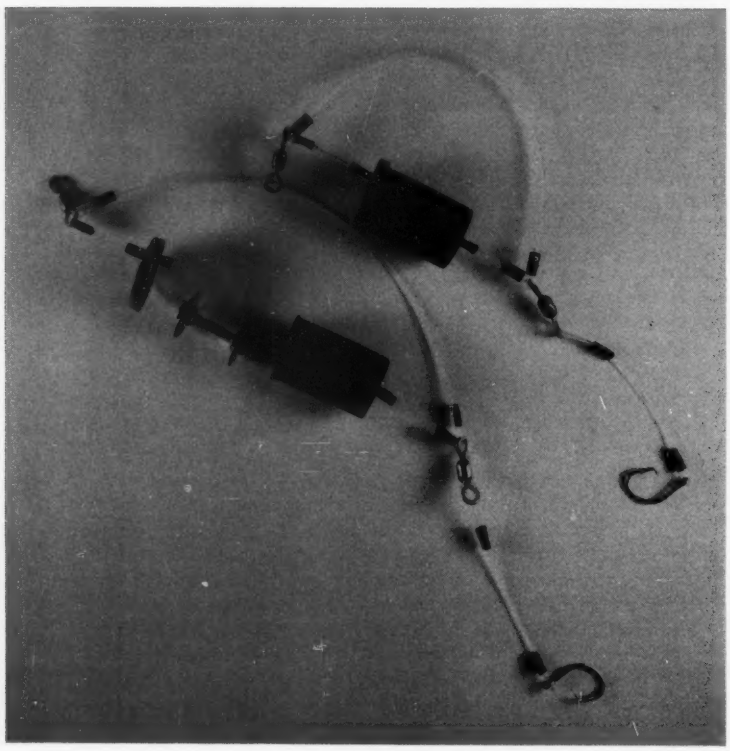

Figure 2.—Corrosion timer cannisters as they would appear when the longline is set (upper) and after a fish has struck the hook (lower).

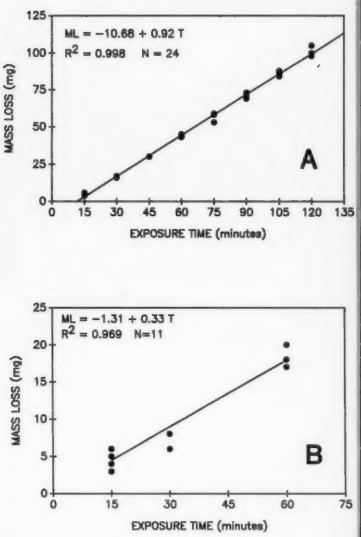

Figure 3.—Anode mass loss of corrosion timers and exposure time to seawater: A) in a laboratory experiment (salinity, 34.7‰; temperature, 23.5°C) and B) at the Hancock Seamount (salinity, 35.0‰; temperature, 15.5°C).

dissolved oxygen concentration, and water movement would likely affect the corrosion rate.

We therefore attempted an in situ calibration by exposing the timers to seawater (salinity, 35.0‰; temperature, 15.5°C) at depth by using a shipboard water sampling rosette. The one successful in situ calibration showed greater variability in mass loss than did the laboratory calibrations, and perhaps some nonlinearity with time (Fig. 3); however, the linear fit of the data was sufficiently good that the in situ calibration rather than the laboratory calibrations was used in the field tests.

Digital Timer

The digital timer (65 mm long × 29 mm diameter) consisted of a digital clock module with a liquid crystal display (Sterling Electronics, Taipei, Taiwan[2]), an alkaline disc battery, and a magnetic reed switch (single pole double throw; Hermetic Switch, Inc., Chickashs, OK 73018), which were enclosed in metal hardware cloth and embedded in a cylinder of polyester casting resin (Fig. 4). A hole at one end of the cylinder contained a ceramic magnet used to activate the reed switch (Fig. 4). When the magnet was pulled out of the

[2]Reference to trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

hole, the reed switch closed and the digital clock started from its reset value of 1:00; when the magnet was reinserted, the clock was reset. The pull required to activate the digital timers was standardized to 1 kg by an adjustable, spring-loaded pin assembly that rested against the magnet (Fig. 4). The rigidity of the timer was sufficient to withstand short-term (about 5-minutes) exposure to chamber pressures equivalent to 1,000 m in depth. The reed switch was partially shielded from external magnetic fields with metal hardware cloth to minimize the chance of the timers being accidentally reset by a struggling fish. Ceramic magnets and stainless steel springs and pins were used to prevent corrosion of either the magnet or the spring-loaded pin assembly that could potentially alter the activation tension of the timer.

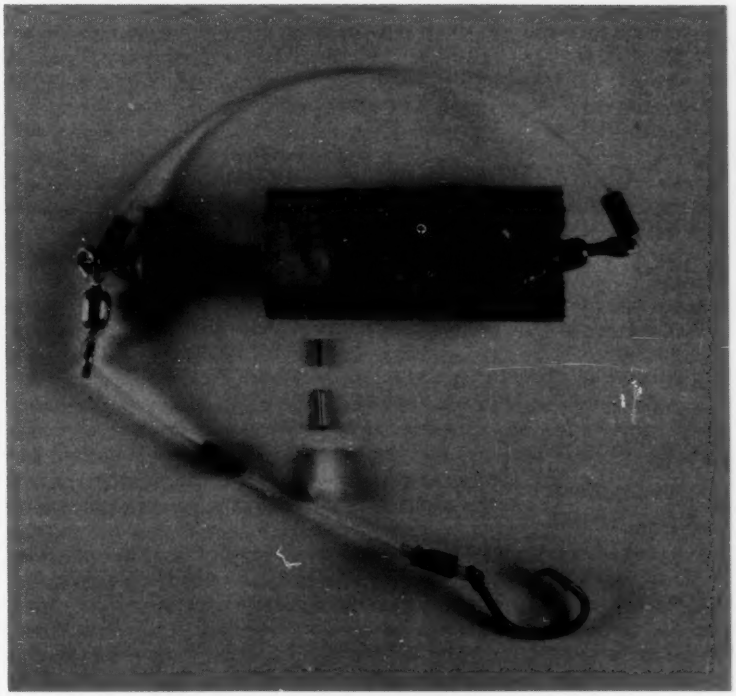

Figure 4.—Digital timer as it would appear 9 minutes after being struck by a fish.

Field Trials

All field trials were conducted on the Southeast Hancock Seamount (lat. 29°48′N, long. 179°E) at depths of 250-800 m. The primary fish species encountered here is pelagic armorhead, *Pseudopentaceros wheeleri*, a small (≈1 kg), sluggish species often forming dense aggregations near the summit.

The timers were tested, based on handling time and failure rates, with Kali longlines, a fishing gear used repeatedly for stock assessment of pelagic armorhead (Shiota[3]). This gear consisted of rigid poles (droppers) snapped on a groundline at 20 m intervals. Each dropper (3.2 m long) had five hooks on short, equally spaced leaders and was weighted so that it was positioned vertically while fishing. The only modification to this gear was the replacement of the normal leaders with leaders having timers spliced in (Fig. 5).

Corrosion timers were field tested once in July (N = 3,264) and once in October 1986 (N = 1,332). Droppers with and without timers were alternated on the groundline to assess the influence

Figure 5.—Corrosion timers in use. Note that the hook leaders are attached to a rigid pole rather than directly to a groundline.

[3]Shiota, P. M. 1987. A comparison of bottom longline and deep-sea handline for sampling bottom fishes in the Hawaiian Archipelago. Honolulu Lab., Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 95822-2396. Southwest Fish. Cent. Admin. Rep. H-87-5, 18 p.

of timers on fishing characteristics of the gear. In the first field test, the corrosion timers sustained accidental damage severe enough to invalidate the mass loss weights; therefore, statistical tests involving time information omit the first trial. Digital timers were field tested in August 1987 (N = 3,840); no side-by-side comparisons were made.

The general times and procedures for using the longline gear were as follows: 1) Baiting hooks (20 minutes), 2) setting (10 minutes), 3) soak time (60 minutes), and 4) retrieval and recording the catch data (30 minutes). The use of hook timers required additional procedures. Corrosion timers were attached to canisters with monofilament leashes (Fig. 2); cannisters were closed while immersed in an alcohol and water mixture. Upon retrieval, individual corrosion timers were removed and placed into a bucket of alcohol to slow corrosion and, after complete recovery of the longline, were air dried and separated from the cathodes to stop corrosion. In the laboratory, corroded anodes were washed, dried, and weighed to the nearest milligram, and the exposure times were estimated by using a previously determined time and mass loss function. For digital timers, the display was read immediately when the gear was brought aboard the vessel, and the timer was reset later by reinserting the magnet into its retaining hole.

Results

Hook timers tended to affect preparation and processing times more than setting and retrieval times. For corrosion timers, attaching new timers increased gear preparation time by about 100 percent, and depending on the size of the catch, deactivating the timers increased processing time by up to about 50 percent. For digital timers, the resetting process increased gear preparation time by about 15 percent, but all other times were unaffected.

Longlines with timers were subject to a variety of failures in addition to the usual modes of failure of the unmodified longlines (e.g., hook loss, bait loss), resulting in losses of time data and sometimes species identity. Two types of failure were premature activation and nonactivation of timers. Premature activation occurred when the timers were prepared improperly (e.g., cannisters not closed completely, magnets not inserted sufficiently to deactivate the reed switch) or were activated accidentally prior to setting. Nonactivation occurred when a fish was too small or too sluggish to activate a timer.

Our experience with both of these failures was as follows: For corrosion timers, 5 percent of 547 activated timers (October 1986 data only) were premature and 16 percent of 1,260 captured fish failed to activate the timers; for digital timers, 6 percent of 2,185 activated timers were premature and 7 percent of 700 captured fish failed to activate the timers. These modes of failure are influenced by the tension required to activate the timers: Increasing tension decreases premature activation but increases nonactivation. The appropriate tension, one balancing these two modes of failure, is a function of the size and activity of the target species and may only be an important consideration for such species as armorhead that are relatively small and sluggish.

Another type of failure was simple mechanical failure or breakage. Corrosion timers rarely failed in this manner, but leashes (Fig. 2) broken when the timer was snagged during recovery resulted in the loss of 13 percent of 1,281 activated timers. We believe this failure rate can be reduced by increasing the strength of the leashes. Digital timers were subject to several types of mechanical failure. Some liquid crystal displays became totally or partially blackened and unreadable after prolonged exposure to direct sunlight and high deck temperatures. Repeated use of timers at $\geq$500 m depths sometimes resulted in a total loss of power to the display or a malfunction of one or more digits on the display. The ceramic magnet sometimes fractured when struck on the deck. Although these failures, taken together, resulted in a loss of 50 percent of the 300 digital timers used in the field trials, each timer was used an average of 19 times before failure occurred, and such failures resulted in a loss of only 7 percent of the 2,185 times obtained. We believe the failure rate of digital timers can be reduced by shielding them from direct exposure to sunlight and casting the electronic components in either a harder or larger cylinder of resin.

In addition to data losses attributable to timer failures, we probably also lost data on species identity if timers were activated by fish not subsequently caught. The frequency of activated timers without fish was quite high: 42 percent of 1,831 activated corrosion timers and 70 percent of 2,185 activated digital timers. Although data are not sufficient to determine whether these hooks were actually struck by fish or were snagged on an object, we speculate that the momentary drop in tension that occurs when a timer is activated may decrease the likelihood of catching a fish.

We examined this possibility by comparing the proportion of hooks recovered with fish for the gear with and without corrosion timers. Thirty-eight percent of 3,337 hooks with timers caught fish, whereas 46 percent of 3,347 hooks without timers caught fish. Although hooks without timers caught significantly more fish ($\chi^2 = 46.1$, $P < 0.01$), it is not clear whether this gear was more attractive and had a higher rate of strikes than timer gear or had a higher retention rate when struck. If all hooks without bait presumably were struck, then 49 percent of 2,519 strikes on hooks with timers retained fish compared with 58 percent of 2,674 strikes on hooks without timers. Thus, the retention rate is significantly lower for hooks with timers ($\chi^2 = 34.0$, $P < 0.01$) and is likely responsible for the relatively low occupancy rate of activated timers. We believe the failure of timer gear to hook fish is, like timers prematurely activated, potentially preventable by increasing the activation tension.

Discussion

Although the abundance estimates we use for stock assessment require time-to-capture data (Somerton[1]), both timers are activated when fish strike and, therefore, measure time-since-capture data. For work in shallow water,

time to capture can be calculated by subtracting time since capture from total elapsed time (surface to surface). For armorhead, however, fishing is conducted at depths of 250-900 m, so time to capture must be corrected for sinking time of gear. Currently, we estimate sinking time with time and depth recorders (Wildlife Computers, Woodenville, WA 98072) attached to the longline, but are considering a modified digital timer, attached to the base of a dropper, that will be activated when the gear hits the bottom.

We now use digital timers exclusively in our armorhead stock assessment because they are preferable to corrosion timers in three respects. First, digital timers are reusable and, if gear loss is low and reuse is high, are cheaper than corrosion timers to collect equal sample sizes. Second, digital timers require less time to set and retrieve than corrosion timers and require no additional processing time. Third, digital timers are more precise because time is measured directly rather than estimated from mass loss. Digital timers, however, are made from parts that may be difficult to obtain and that require skill and specialized equipment to assemble, whereas corrosion timers are made from inexpensive, readily available materials and can be fabricated by inexperienced personnel.

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Marine Recreational Boat Fishery of the New York Bight Apex in 1971

CHESTER C. BUCHANAN, RICHARD B. STONE, and FRANK W. STEIMLE

ABSTRACT—*The marine recreational boat fishery in the heavily populated New York City metropolitan area has not been well described. This paper describes the 1971 catch composition and the distribution of estimated effort over spatial and seasonal scales and between major vessel types (party, charter, and private boats) engaged in the fishery. Anglers spent an estimated 2.3 million hours fishing in the New York Bight apex in 1971, over half of this by party boat anglers, and caught almost 8 million game fish. Overall effort was about equal for pelagic and demersal species and was generally concentrated nearshore. There appeared to be a substantial change in the fishery since the late 1940's and early 1950's, possibly reflecting socioeconomic trends and population dynamics of the fish species.*

Introduction

Ocean waters adjacent to the densely populated and industrialized New York-New Jersey metropolitan area (the New York Bight apex) support one of the most concentrated marine recreational boat fisheries in the United States (Freeman and Walford, 1974). Despite the popularity and intensity of this fishery, little is known of its total catch and efforts. Information on this fishery is required because of multiple use issues in the New York Bight waters including fishery resources and habitat.

Although the area's fish resources have attracted recreational fishermen since colonial times (Pearson, 1972), this fishery was not specifically documented until the late 1930's (Westman, 1938). Butler and Spear (1950) were the first to document fishing success and catch composition for the party and charter boat fleets of the New York Bight in 1948. Redfield and Walford (1951) also estimated total catch, catch rates, catch composition, and effort rates for party and charter boats sailing from Bight ports between Jones Inlet, N.Y., and Manasquan Inlet, N.J., during 1949. The New Jersey party and charter fleet was also surveyed in 1952 by Younger and Hamer (1952) and in 1954 by Younger and Zamos (1955). These surveys yielded estimates of fishing success and catch composition. No estimates of total catch and effort were available, however, except later for two species: Bluefish, *Pomatomus saltatrix*; and summer flounder, *Paralichthys dentatus* (Christensen and Clifford, 1979 a,b). The private boat fleet had never been accurately surveyed because of the difficulties in adequately sampling the fishermen.

The purpose of our survey was to 1) document the 1971 recreational boat fishery in the New York Bight apex by estimating effort, catch (total and composition), and fishing success (catch rates), for that fishery and 2) to compare these estimates, where applicable, to estimates from past surveys. This survey was an expanded part of a 2-year study of angler use of New York Bight artificial habitats relative to other habitats. The initial 1970 survey data were focused exclusively on artificial reef use and were reported in Stone et al. (1974). This study suggests that there have been changes in the proportional composition of boat types engaged in the fishery since 1949, with an increase in private boat participation. It can also serve as a basis for comparison for more recent studies of the area's recreational fishery.

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Survey Area

The survey area, the New York Bight apex, extends from the New York coast southward to lat. 42°00′N and eastward from the New Jersey coast to long. 73°30′W (Fig. 1), and encompasses about 1,300 km^2. The ocean bottom is a gently sloping, sandy plain interrupted at the 30 m isobath by the northern terminus of the submerged Hudson Shelf Valley that has depths to 70 m in the apex. Soft substrate predominates the deeper half of the survey area. A natural horseshoe shaped rock formation begins a few kilometers off Manasquan Inlet and extends to a few kilometers off Jones Inlet, covering about 60 km^2 between the 9 and 27 m contours. Much of this formation is covered by sand; however, large patches of gravel, stones, and rocky outcroppings are exposed in some areas.

Over the last few centuries, man has increased the amount of rocky habitat in the survey area by nearly 8 km^2 with the disposal of debris and the sinkings of hundreds of ships. Regular dumping of building rubble, subway excavation tailings, and other solid wastes in the northern portion of the survey area has created expansive areas of irregular shaped hard bottom. Most of the ships sunk by military action or accident have decomposed to rubble piles

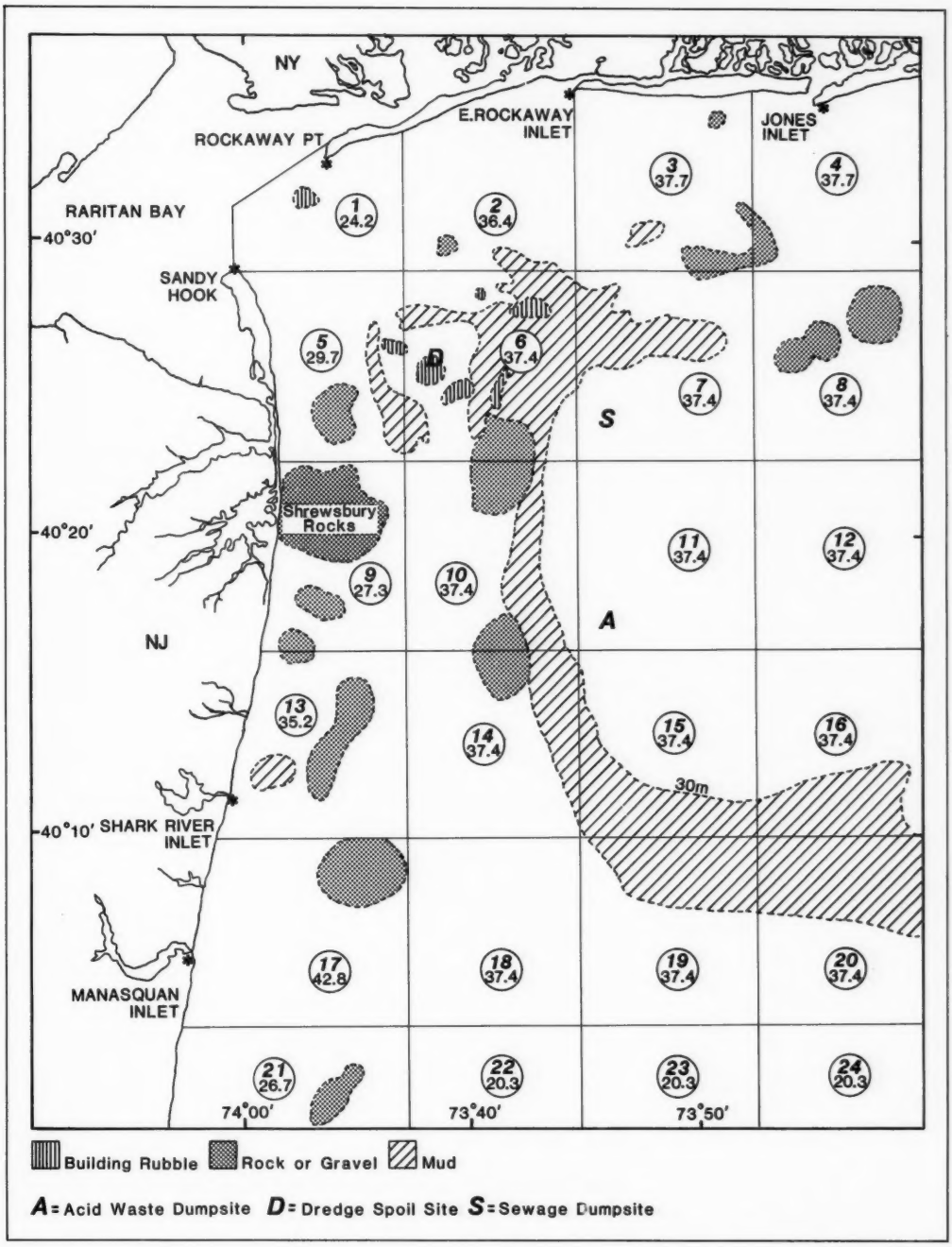


Figure 1.—Location of survey area and observation stations (*) in the apex of the New York Bight. Also shown are sectors with estimated square kilometers in parenthesis and approximate boundaries of predominate sediment components and locations of artificial reefs. Data compiled from: 1) NOAA charts; 2) Freeman and Walford (1974); 3) Personal commun., local party and charter boat captains; 4) Personal commun., A. Cok, Adelphi University, Garden City, Long Island, NY 11530; and 5) Hathway (1972).

that protrude only about 1 m above the bottom, while a few are still intact and protrude substantially off the bottom. Rocky habitat has been intentionally increased (about 0.03 km^2) since the 1920's in the Bight apex with the establishment of several artificial reefs in 10-20 m of water (Stone et al., 1974). They are composed of barges, tires, concrete culvert, and car bodies that protrude 1-5 m above the bottom.

The survey area also currently encompasses the largest ocean waste disposal grounds in the United States (Mayer, 1982). For decades sewage sludge and dredging spoils have been regularly dumped at two sites in the survey area (Fig. 1). Sewage dumping in the survey area will be phased out by 1988. However, millions of cubic yards of dredging spoil from New York-New Jersey metropolitan area harbors may continue to be dumped annually. Up to 1982 and during the study period, industrial acid waste (8.5 percent H_2SO_4 and 10 percent F_3SO_4) were also disposed of daily in a general area 20 km east of New Jersey and 24 km south of New York (southwest corner of sector 11, Figure 1).

General Description of the Recreational Fishery

Recreational boat fishing in the New York Bight apex perhaps had its beginnings in the 1700's when professional fishermen occasionally hired out their boats, along with their services, to recreational fishermen (Pearson, 1972). The fishery appeared to grow slowly in popularity, however, until the second quarter of the 20th century when improved vessel design and safety coincided with economic and social changes. The 1950's saw further improvements including two-way radios, depth recorders, and improved fishing tackle. Party and charter boats are becoming larger, more comfortable, and faster than their predecessors. The number of private boats in the fishery has also increased due to small boat improvements since World War II. Recent improvements made it possible for many fishermen to buy larger, seaworthy boats capable of venturing offshore.

A substantial fleet of recreational boats, sailing out of ports from Manasquan Inlet to Jones Inlet, fishes primarily in the survey area. Few recreational boats from ports outside the boundaries of these inlets fish in the sampling area. The 1971 recreational fleet consisted of 122 party boats, 102 charter boats (both full- and part-time), and an unknown number of private boats. Party boats are larger vessels, up to about 30 m in length, publically available on a daily basis with a carrying capacity of up to 149 fishermen, while charter boats are medium sized (10-20 m) vessels available for hire by an individual or small group for their specific fishing interests; they typically carry 4-6 fishermen. Professional crews, usually with many years of experience, operate these boats; most use depth recorders and navigational equipment for locating fish schools and fishing sites. Private boats generally range in size from 5 to 15 m and usually carry up to 6 fishermen. These boats are usually not operated by professional crews and less than half were equipped with sensitive sonar, depth recorders, or navigational equipment at the time of the survey.

Although the fishery is pursued almost year round, most fishing activities are curtailed during winter (approximately late December to late February) because of adverse weather. Few party boats sail at this time of year and only an occasional charter or private boat. Most recreational boats operate only during the warmer months: May through October.

The majority of the recreational fleet fishes only during daylight. Party and charter boats usually maintain a regular schedule of leaving the dock at 0800 hours and returning at 1630 hours. During the summer a few party boats fish two half-day trips, while others fish at night, as well. Night fishing occurred mainly from June through October by party boats seeking bluefish. Few, if any, charter or private boats were active in this night fishery. Fish are attracted to the party boats at night by chumming with ground-up Atlantic menhaden, *Brevoortia tyrannus*, or other bait and illuminating the water around the boat with high intensity electric lights.

During warm months, the recreational boat fishery depends upon a mixture of boreal, oceanic, and temperate species. Diversity of the catch is made possible by cold bottom water (7°-10°C) in the deep extremeties of the survey area beneath the 20-25 m thermocline overlaid by warm water (20°-22°C). Boreal species (e.g., Atlantic cod, *Gadus morhua*, and pollock, *Pollachius virens*), inhabit the cold bottom water, while oceanic species (e.g., tunas and Atlantic bonito, *Sarda sarda*), and temperate pelagic and demersal species (e.g., Atlantic mackerel, *Scomber scombrus*; bluefish; summer flounder; black sea bass, *Centropristis striata*; scup, *Stenotomus chrysops*; and striped bass, *Morone saxatilis*) inhabit either warmer surface or the nearshore waters (Table 1).

Table 1.—Common and scientific names of game or nongame marine fishes reported caught during the 1971 recreational boat fishery survey.

Common and scientific name	Game	Nongame
American eel, *Anguilla rostrata*		X
Atlantic bonito, *Sarda sarda*	X	
Atlantic cod, *Gadus morhua*	X	
Atlantic herring, *Clupea harengus*	X	
Atlantic mackerel, *Scomber scombrus*	X	
Atlantic menhaden, *Brevoortia tyrannus*		X
American shad, *Alosa sapidissima*	X	
Black sea bass, *Centropristis striata*	X	
Bluefin tuna, *Thunnus thynnus*	X	
Bluefish, *Pomatomus saltatrix*	X	
Cunner, *Tautogolabrus adspersus*		X
Dolphin, *Coryphaena hippurus*	X	
Goosfish, *Lophius americanus*		X
Jacks, Carangidae		X
Little tunny, *Euthynnus alletteratus*	X	
Northern kingfish, *Menticirrhus saxatilis*	X	
Northern puffer, *Sphoeroides maculatus*		X
Northern searobin, *Prionotus carolinus*		X
Northern stargazer, *Astroscopus guttatus*		X
Ocean pout, *Macrozoarces americanus*		X
Oyster toadfish, *Opsanus tau*		X
Pollock, *Pollachius virens*	X	
Redfish, *Sebastes marinus*	X	
Red hake, *Urophycis chuss*	X	
Sculpins, Cottidae		X
Scup, *Stenotomus chrysops*	X	
Sharks, Squaliformes		X[1]
Silver hake, *Merluccius bilinearis*	X	
Skates and rays, Rajiformes		X
Skipjack tuna, *Euthynnus pelamis*	X	
Striped bass, *Morone saxatilis*	X	
Summer flounder, *Paralichthys dentatus*	X	
Tautog, *Tautoga onitis*	X	
Weakfish, *Cynoscion regalis*	X	
Windowpane, *Scophthalmus aquosus*		X
Winter flounder, *Pseudopleuronectes americanus*	X	
Yellowtail flounder, *Limanda ferruginea*		X

[1]Sport fishery for sharks was just starting to develop.

Methods

To determine fishing success, catch, catch composition, and fishing effort we used telephone interviews, mail questionnaires, and boat counting surveys from April through December, 1971. From the responses we calculated fishing effort (measured in angler-hours) from boat counts, the average number of fishermen per boat, and the average number of hours fished per fisherman. We assumed most anglers used only one fishing rod; however, this may be a source of some error in our data, as some do use two or more rods. The number of boat-days each month was estimated by expanding the number of party, charter, and private boats counted leaving Manasquan, Shark River, East Rockaway, and Jones Inlets or rounding Sandy Hook and Rockaway Point (Fig. 1) during randomly stratified periods. Sampling was stratified by observation station (port), month, day (weekend, holiday, and weekday), and hour (0600-1800 hours). The mean boat-days per unit were expanded by the number of units per strata for all strata and yielded a estimate of the boat-days per month per boat type (Table 2). The number of fishermen was estimated by multiplying the estimated number of boat-days by the average number of fishermen per boat. The number of angler-hours was estimated by multiplying the estimated number of fishermen by the average number of hours fished per fisherman, obtained from mail questionnaires (for private boats) and telephone interview (for party and charter boats).

Table 2.—Number of boats interviewed by month and boat type, 1971.

Month	Charter	Party	Private
April	4	138	37
May	36	247	140
June	147	184	529
July	67	155	448
Aug.	80	145	448
Sept.	61	134	189
Oct.	24	105	163
Nov.	20	66	114
Dec.	7	85	29
Total	446	1,259	2,097

We interviewed party and charter captains by telephone to determine the number of fishermen on board, fishing method, time fishing, and catch (by species) at each of their fishing sites per day. Using a systematic sampling design stratified by port, month, week, and day (weekend, weekday, and holidays), we selected 8 sampling days per month. We attempted to interview 25 party and 25 charter boat captains (selected on these days at random) for either that day's or previous day's fishing activities, or both. Our sample size was determined by the number of captains that could be interviewed in one night with available personnel.

We estimated fishing success and catch composition of private boat fishermen through mail questionnairs. During our boat counting surveys, we developed a list of registration numbers observed each day on boats that passed a survey point and appeared to be going out to fish (i.e., fishing rods and related gear evident). We then selected registration numbers at random from this list to determine who would be mailed questionnaires. Using these registration numbers, we obtained names and addresses of the boat owner from vessel registration lists maintained then by the New Jersey Marine Police and New York Department of Conservation on the same day or the day after the vessel was observed leaving the port. We then mailed each boat owner: 1) A questionnaire within a day or so requesting information about all the fishing activities for the day the boat was observed, 2) a letter explaining the purpose of the survey, 3) a pictorial key of the more common game fishes (to improve confidence in names fishermen supplied to their catch), 4) a map of the survey area with the popular fishing grounds marked (to help fishermen report where they fished accurately), and 5) a postpaid return envelope. We mailed a second request to boat owners who did not respond within 2 weeks of our initial inquiry.

Fishing methods were classified as either surface or bottom fishing. Surface fishing included trolling and jigging for pelagic species, whereas bottom fishing was usually conducted while anchored or drifting. When classification of method or segregation of catch and effort by method was not possible, we listed the method as "mixed." We considered game fishes in our survey (Table 1), as we assumed most fishermen did not report accurate numbers of nongame fishes caught. To better describe the fishery, we divided the survey area into 24 sectors which ranged in size from 39 to 68.5 km^2 (Fig. 1).

To test validity of the survey data, we surveyed party boats directly on 16 occasions to gauge the accuracy of information reported during the telephone survey of party boat captains. To do this, we chose at random party boats to be sampled from a group whose crew did not know the identity or affiliation of our sampler. Pretending to be an average fisherman, the sampler paid the fare and boarded the selected boat along with other fishermen. While at sea and intermittantly while fishing, the sampler watched and talked to the other fishermen, and kept track of the number of each species caught, number of fishermen, and hours fished. Later that evening, we telephone interviewed the same captain for the same information for comparison.

From this test, we found no significant difference between the number of hours ("t" test; $P = > 0.50$), number of fishermen (χ^2 test; $\chi^2 = 14.425$, $P > 0.25$), and the relative abundance of each species reported ("t" test: $P > 0.50$) between the telephone survey and those actually observed. We did find a significant difference in the number of game fish reported caught ($\chi^2 = 193.8$, $P < 0.005$). Party boat captains had a tendency to overestimate their catch of game fish by an average of 14 percent. We concluded that the catch of each species had been overestimated proportionately since we found no difference in the species composition. Overestimates did not seem to influence our estimate of catch rates since we found no significant difference between the two sets of catch rates (Wilcoxon paired test; $t = 28.5$, $P > 0.26$).

Catch rate of a species is calculated by dividing the number of that species caught by the number of angler-hours expended fishing specifically for the

species. It is usually not possible in a multiple species fishery to segregate effort specifically for each species or group of species. Butler and Spear (1950), Redfield and Walford (1951), and Younger and Hamer (1952) calculated species catch rates using the assumption that a fisherman was seeking a particular species if the species represented at least 75 percent of the fisherman's catch. Use of this assumption may bias species catch rates since undue emphasis is given to the successful fisherman. If the ratio of successful fishermen to unsuccessful fishermen varies significantly with time, the resulting species catch rate may only reflect changes in the species catchability and/or expertise of the fishermen (including the number of rods used), but not changes in the relative abundance of a species.

For historical comparison purposes, however, we had to assume that influence from the above potential bias to be slight. We calculated species catch rates from our data using the assumption criterion of Butler and Spear (1950). Our catch rate comparisons are only for party and charter boat anglers and species discussed in previous studies (Westman and Neville, 1942; Butler and Spear, 1950; Redfield and Walford, 1951; Younger and Hamer, 1952).

We did not test the accuracy of information reported through the mail questionnaire or by charter boats, because of the obvious problem of not being able to put an independent observer on board. The results of a similar survey (Buchanan et al., 1974) indicated that response and nonresponse errors had little effect on accuracy. Of nine response categories tested, only estimates of catch were significantly different from those counted at dockside (13 percent overestimated). These findings were similar for party and charter boat captain data.

Estimates derived from a sample are subject to sampling error. We did not measure the magnitude of this error in our data. Since our monthly samples were relatively small (Table 2), sampling error may have been large. We believe, however, that our sampling procedures and sample size were sufficient to give realistic estimates which are not extreme and are useful as preliminary indicators of the fishery.

Table 3.—Estimated number of angler-hours expended per boat type, fishing method, and month during 1971.

Item	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Charter										
Surface	310	6,200	25,857	14,721	25,515	17,732	4,544	3,328	0	98,207
Bottom	1,421	5,543	17,566	569	1,050	2,392	1,141	1,596	555	31,833
Mix	0	420	1,170	0	255	504	0	0	915	3,264
Party										
Surface	11,760	187,550	88,862	74,375	73,125	53,340	25,160	6,160	10,450	530,782
Bottom	58,616	76,534	102,948	122,009	96,465	52,788	44,495	27,460	22,816	604,131
Mix	11,220	39,026	0	680	2,310	4,343	0	350	40,920	98,849
Private										
Surface	9,856	43,192	129,936	131,779	142,599	58,912	57,803	40,655	168	614,999
Bottom	749	5,971	90,347	85,801	60,590	20,227	14,585	12,548	7,617	298,415
Mix	602	3,235	9,132	6,633	7,553	6,896	2,580	86	8,391	45,105
Subtotal										
Surface	21,926	236,942	244,655	220,875	241,239	129,984	87,507	50,144	10,618	1,243,890
Bottom	60,786	88,048	210,861	208,379	158,105	75,407	60,201	41,604	30,988	934,385
Mix	11,822	42,681	10,302	7,313	10,118	11,743	2,580	436	50,226	147,221
Grand total	94,534	367,671	465,817	436,567	409,462	217,134	150,288	92,184	91,832	2,325,496

Results

Effort

We estimated that party and charter boat fishermen sailing from ports between Manasquan and Jones Inlets expended about 85 percent of their fishing effort in the survey area, while private boat fishermen expended about 94 percent of their effort in this area. This suggested that recreational boat fishermen expended over 2.3 million angler-hours fishing between April and December 1971 in the survey area (Table 3); 53 percent of this effort was by party boat anglers, 41 percent by private boat anglers, and 6 percent by charter boat anglers.

Overall, recreational boat fishermen expended 53 percent of their total fishing effort seeking pelagic species. They concentrated most of their surface fishing activities along the coastline and in the central portion of the survey area (Fig. 2). Party boat fishermen concentrated their surface fishing effort over the Shrewsbury Rocks, Mud Hole, (the deeper parts of sectors 6 and 10), the sewage sludge disposal area, and just outside Manasquan Inlet (Figure 2, sectors 7-10, 15, 17, and 21). Charter boat

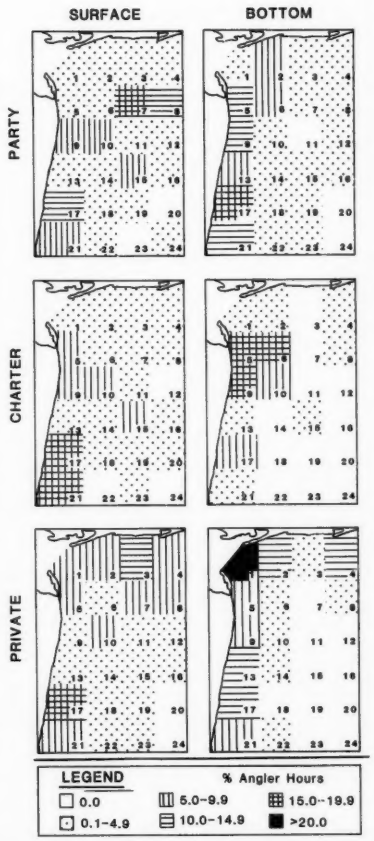


Figure 2.—Percent angler-hours expended per boat type and fishing method per sector (see Fig. 1).

Table 4.—Estimated proportion of angler-hours (%) expended per boat type and fishing method while over artificial reefs (AR), wrecks (WK), natural habitat (NH), and unknown (UNK) from April through December, 1971.

	Boat type		
Item	Charter	Party	Private
Surface			
AR	0.9	0.0	4.9
WK	0.0	0.0	0.2
NH	99.1	99.9	93.4
UNK	0.0	0.1	1.5
Bottom			
AR	5.0	4.7	2.2
WK	3.1	15.6	2.7
NH	91.2	78.3	93.9
UNK	0.7	1.4	1.2

Table 5.—Estimated number (in thousands) and percent of total catch of major species caught per boat type, April through December 1971, in the New York Bight apex.

	Boat type							
	Party		Charter		Private		Season	
Species	Number	%	Number	%	Number	%	Number	%
Atlantic mackerel	4,383.2	66.1	6.8	4.2	157.4	19.2	4,547.4	59.7
Bluefish	433.4	6.5	91.6	56.0	290.0	35.4	815.0	10.7
Red hake	614.0	9.3	20.2	12.4	15.3	1.9	649.5	8.5
Silver hake	469.6	7.1	25.0	15.3	39.4	4.8	534.0	7.0
Scup	350.3	5.3	1.6	1.0	18.8	2.3	370.7	4.9
Summer flounder	119.1	1.8	3.0	2.0	144.0	17.6	266.1	3.5
Tautog	137.2	2.	1.6	1.0	26.1	3.2	164.9	2.2
Black sea bass	66.5	1.0	2.2	1.0	6.0	0.7	74.7	1.0
Striped bass	0.4	0.0	3.7	2.3	62.1	7.6	66.2	0.9
Atlantic cod	28.2	0.4	0.4	0.2	7.4	0.9	36.0	0.5
Little tunny	3.7	0.0	4.1	2.5	8.0	1.0	15.8	0.2
Bluefin tuna	0.2	0.0	1.4	0.9	7.3	0.9	8.9	0.1
Others	23.6	0.4	2.0	1.2	37.8	4.6	63.4	0.8
Total	6,629.4		163.5		819.5		7,612.4	

anglers also concentrated their surface fishing effort off Manasquan Inlet, Shrewsbury Rocks, and Mud Hole, but along the Sandy Hook coastline, as well (Figure 2, sectors 5, 9, 10, 15, 17, and 21). They did not expend many angler-hours (less than 5 percent) surface fishing in sectors containing the dump sites. Surface fishing effort by private boat anglers was concentrated in the northern third of the survey area and off Manasquan Inlet (Fig. 2).

Bottom fishing, which accounted for 39 percent of total fishing effort, was concentrated mainly between the 10 and 30 m contours off the New Jersey coast (Fig. 2). Party boat captains concentrated their effort in the areas of Sandy Hook, Shrewsbury Rocks, and Manasquan Inlet (Figure 2, sectors 2, 5, 6, 9, 13, 17, and 21). Charter boat anglers also limited most of their fishing effort to areas off Sandy Hook and Shrewsbury Rocks, but also fished in the vicinity of the dredge spoil disposal and Mud Hole Areas (Figure 2, sectors 5, 6, 9, and 10) and off Manasquan Inlet (sector 17), whereas most of the private boat anglers remained within a short distance of the inlets or Sandy Hook and Rockaway Points (Fig. 2).

Party boat anglers expended over 1.2 million angler hours in the survey area: 43 percent surface fishing, 49 percent bottom fishing, and 8 percent using a combination of the two methods (Table 3). They fished for pelagic and demersal species during the entire season. Most of their effort for pelagic species was from May through October with a large peak in May for Atlantic mackerel. They distributed their effort for demersal species more evenly through the season than for pelagic species. There was a slight increase in effort from the beginning of the season to July; afterwards, their effort gradually decreased.

Charter boat anglers expended over 133,000 angler-hours for pelagic and demersal species from April through December: 74 percent surface fishing, 24 percent bottom fishing, and 2 percent mixed methods. Most of their effort for pelagic species was from June through September and mostly for bluefish (Tables 3 and 6), with peaks in June (26 percent) and August (26 percent). They scattered their effort for demersal species irregularly through the season with a peak in June (55 percent) and low in July (2 percent).

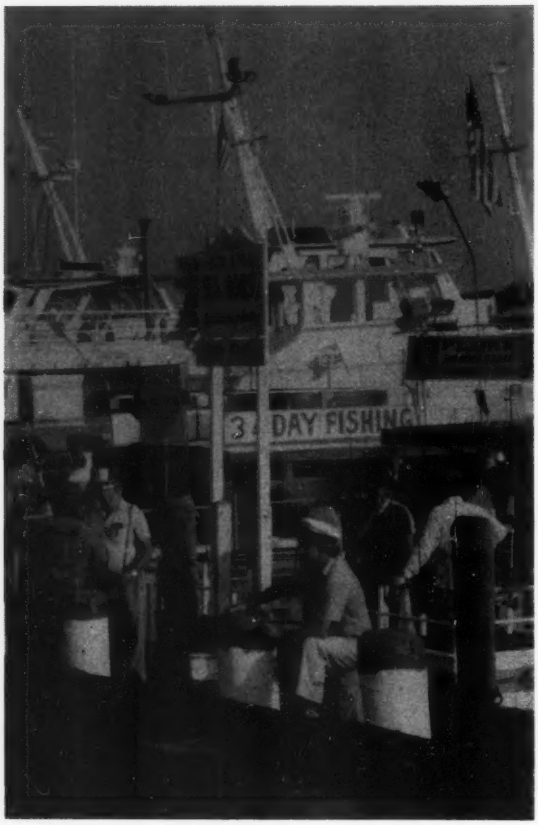
Private boat anglers spent nearly 1 million angler-hours fishing for pelagic and demersal species during the season: 64 percent surface fishing, 31 percent bottom fishing, and 5 percent mixed methods (Table 3). Peak effort for pelagic species occurred in August (23 percent) for bluefish and in June (30 percent) for demersal species, mostly summer flounder.

Artificial habitats (wrecks and artificial reefs) in the survey area were important to the recreational boat fishery. They received between 2.7 and 15.6 percent of the bottom fishing effort (Table 4). They were not as important to surface fishermen. This effort varied between the two types of artificial habitat (wrecks or reefs), as well. No seasonal trends in effort on artificial habitats were evident.

Catch

We estimate that, in 1971, New York Bight recreational boat fishermen caught about 7.6 million fish of 24 game species (Table 5). Party boat anglers accounted for 6.63 million of the catch, charter boats for 0.16 million, and private boats for 0.82 million (Table 5). Of the 24 game species reported (Table 1), only 12 were caught consistently enough to be used in comparisons with previous surveys. The rest were included together as "others" in Tables 5, 6, 7, and 8. Atlantic mackerel comprised 60 percent of the total catch (Table 5) and were the most numerous species taken in spring and early winter when silver hake, *Merluccius bilinearis*, were also abundant. Bluefish, summer flounder, and red hake, *Urophycis chuss*, were abundantly caught in the summer, and scup in the fall (Tables 6, 7, and 8). It appears that an Atlantic mackerel recreational fishery did not exist prior to 1940 (Westman, 1958).

[1]Westman, J. R. 1958. A study of the newly created "Acid Grounds" and certain other fishery areas of the New York Bight. Unpubl. rep., 50 p.



Party boats: A typical scene at major New York and New Jersey ports.

Table 6.—Estimated number (thousands) of each species caught per month by party boat fishermen while surface, bottom, or mixed method fishing during 1971 (T = <100 caught).

Item	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Atlantic cod										
Surface	0.3								T	0.3
Bottom	6.0	8.7	0.1	3.7	0.2	0.5	T	1.9	1.1	22.2
Mix	T	0.1						T	6.1	6.2
Atlantic mackerel										
Surface	162.2	2,845.4	31.6					11.1	218.8	3,269.1
Bottom		0.3					T	T	2.7	3.0
Mix	133.0	714.5						0.1	263.4	1,111.0
Black sea bass										
Surface					T	0.4				0.4
Bottom	0.4	3.4	20.1	8.0	4.5	14.5	10.8	3.7	0.6	66.0
Mix						0.1				0.1
Bluefin tuna										
Surface				T	0.1	T				0.1
Bottom										0.0
Mix				T						T
Bluefish										
Surface		0.6	125.7	146.5	82.3	30.5	32.3	5.7		423.6
Bottom		T		2.4	T	T	5.2	0.1		7.7
Mix					1.0	0.9				1.9
Red hake										
Surface										0.0
Bottom	66.7	199.0	83.6	88.6	53.9	4.9		3.1	54.0	553.9
Mix	0.8	0.9		3.0					55.4	60.1
Little tunny										
Surface					0.1	2.4	1.2			3.7
Bottom										0.0
Mix										0.0
Scup										
Surface						T	T			T
Bottom			0.4	0.4	5.1	73.3	121.9	149.1		350.2
Mix						T				T
Silver hake										
Surface	0.1	15.7							0.3	16.1
Bottom	31.9	143.6	44.3	0.1	0.1	0.1		0.9	95.9	316.9
Mix	16.6	61.1							59.1	136.8
Striped bass										
Surface					T		T	0.1		0.1
Bottom		T	0.1				T	T		0.1
Mix										0.0
Summer flounder										
Surface				T	T	0.4				0.4
Bottom			50.7	52.1	10.3	4.5	T			117.6
Mix					1.0	0.1				1.1
Tautog										
Surface										0.0
Bottom	3.1	17.1	24.3	8.6	1.7	8.6	43.2	27.4	2.9	136.9
Mix									0.4	0.4
Others										
Surface	0.3	0.3		T	2.3	0.3	0.6	1.0	3.7	8.5
Bottom	3.6	0.6	0.1	0.1	0.2	0.1	0.7	0.2	T	5.6
Mix	2.5					0.2			6.7	9.4
Total										
Surface	162.9	2,862.0	157.4	146.6	84.8	34.1	34.2	17.9	222.8	3,722.7
Bottom	111.6	372.8	224.0	164.0	75.9	105.9	181.9	186.4	157.1	1,579.6
Mix	152.9	776.6		3.0	2.1	1.3		0.1	391.2	1,327.2
									Grand Total	6,629.5

Party boats caught 56 percent of their catch surface fishing (Table 6). Atlantic mackerel constituted 88 percent of the surface fishing catch, while bluefish, the second most numerous species caught, constituted 11 percent or almost all of the remaining catch. Seasonally, Atlantic mackerel also dominated the party boat catch in the spring and winter, with bluefish dominant in the summer and fall. Six species (red hake, silver hake, scup, tautog, *Tautoga onitis*; summer flounder, and black sea bass) constituted 98 percent of the bottom catch by party boats (Table 6). Red hake, tautog, and black sea bass were caught throughout the season, with the exception of October when no red hake were reported caught. Silver hake, summer flounder, and scup were caught seasonally; party boats caught silver hake during the winter and spring, summer flounder during the summer months, and scup during the fall.

Charter boat anglers caught 64 per-

Table 7.—Estimated number (thousands) of each species caught per month by charter boat fishermen while surface, bottom, or mixed method fishing during 1971 (T = <100 caught).

Item	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Atlantic cod										
Surface										0.0
Bottom	0.1							T	0.1	0.2
Mix										0.0
Atlantic mackerel										
Surface	2.2	0.4								2.6
Bottom		T						T	0.1	0.1
Mix		T							4.1	4.1
Black sea bass										
Surface				T	0.2	0.2		T		0.5
Bottom			1.0			T	0.3			1.3
Mix			0.3			T				0.4
Bluefin tuna										
Surface				0.2	1.1	T				1.4
Bottom										0.0
Mix			T							T
Bluefish										
Surface		4.7	38.8	27.3	10.1	4.6	4.6	1.3		91.4
Bottom			0.1			0.1	T	0.1		0.1
Mix					T	T				T
Red hake										
Surface		0.2			0.6	T				0.8
Bottom		1.2	3.6	0.8	1.3	0.8	0.1	1.8	1.6	11.1
Mix	0.2	1.4			0.3	0.2			1.3	3.4
Little tunny										
Surface					0.2	3.7	0.2			4.1
Bottom										0.0
Mix						T				T
Scup										
Surface										0.0
Bottom						T	1.5			1.6
Mix										0.0
Silver hake										
Surface		T					0.1			0.1
Bottom		5.0	8.7						0.1	13.8
Mix		T				T				0.1
Striped bass										
Surface		0.1	0.3	2.0	0.1	T	T	0.6		3.0
Bottom		T	0.6	T						0.6
Mix		0.1								0.1
Summer flounder										
Surface					T	0.1				0.1
Bottom			1.0	0.3	1.3	0.4				2.9
Mix						T				T
Tautog										
Surface				0.1			0.1	T		0.3
Bottom		0.2	0.3				0.6	T	0.2	1.3
Mix			T							T
Others										
Surface		T		0.1	1.5	0.2	0.1	0.0	0.0	1.9
Bottom		T	T			T	T	T		T
Mix										0.0
Total										
Surface	2.2	5.2	39.1	29.7	13.3	8.9	5.1	1.9		105.3
Bottom	0.1	9.1	25.8	0.4	1.3	0.4	2.5	0.1	0.5	40.3
Mix		T	2.0		0.1	0.1			15.6	17.8
									Grand Total	163.4

Table 8.—Estimated number (thousands) of each species caught per month by private boat fishermen while surface, bottom, or mixed method fishing during 1971 (T = <100 caught).

Item	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Atlantic cod										
Surface	T	T	T					0.8		0.8
Bottom	0.5	0.1						1.3	2.3	4.2
Mix	T	0.2							2.2	2.4
Atlantic mackerel										
Surface	32.2	106.6	0.9					1.6	1.4	144.7
Bottom					0.1				1.6	1.7
Mix	0.2	4.6	1.5	0.2					4.6	11.1
Black sea bass										
Surface										0.0
Bottom		0.1	1.3	0.6	1.1	0.4	1.7	0.5		5.8
Mix					T	0.2				0.2
Bluefin tuna										
Surface			0.6	3.1	2.9	0.3	0.1			7.0
Bottom										0.0
Mix					0.2	0.1				0.3
Bluefish										
Surface		14.5	72.7	88.0	55.3	14.6	24.6	7.7		277.4
Bottom		T	0.5	1.3	0.8	1.2	0.4	0.3		4.6
Mix		0.4	3.7	1.0	1.2	1.1	0.6			8.0
Red hake										
Surface										0.0
Bottom	T	3.9	14.1	0.1				0.1	0.1	18.3
Mix		T	1.5		T				5.1	6.7
Little tunny										
Surface				0.1	0.8	6.9	0.1			7.9
Bottom										0.0
Mix						0.1				0.1
Scup										
Surface				T		0.2				0.2
Bottom		T	T	0.3	6.1	7.5	3.8	0.3		18.0
Mix						0.6				0.6
Silver hake										
Surface	0.3	6.7			0.2					7.2
Bottom	0.4	12.9	4.0	1.9	0.2	1.0		2.0	1.5	24.0
Mix	1.3	4.3	0.3		T	0.5			1.8	8.2
Striped bass										
Surface		0.7	6.2	13.5	4.3	2.5	5.3	9.0		41.5
Bottom		0.1	1.9	1.3	0.6	14.0	1.1	0.1		19.2
Mix		0.1	0.3	0.3	0.1		0.6			1.4
Summer flounder										
Surface			0.6	0.8	0.8	0.2				2.4
Bottom		0.3	44.7	56.1	29.5	6.3	0.9			137.8
Mix		T	0.5	1.2	1.8	0.2	0.1			3.8
Tautog										
Surface			0.1	0.1		T				0.2
Bottom		1.0	3.9	1.0	1.1	1.1	12.3	5.2		25.6
Mix						0.3				0.3
Others										
Surface	0.2	0.2	T	0.9	8.7	3.5	3.7			17.2
Bottom		1.9	5.1	0.9	0.9	2.4	2.4	3.4		17.0
Mix		0.2		T	0.2	T	0.5		2.6	3.6
Total										
Surface	32.7	130.9	81.1	106.5	73.6	28.2	33.8	19.1	1.4	507.3
Bottom	0.9	17.8	65.0	64.3	41.7	34.7	22.7	14.9	6.9	268.9
Mix	1.7	11.2	6.3	2.7	3.8	3.3	1.8		12.5	43.3
									Grand Total	819.5

cent of their fish while surface fishing, mainly bluefish (87 percent), while little tunny, *Euthynnus aletteratus*; striped bass, Atlantic mackerel, bluefin tuna, *Thunnus thynnus*; and a small percentage of "others" completed the list (Table 7). Silver and red hakes constituted 80 percent of the bottom fishing catch by charter boats, most of which were

caught during May and June.

In contrast to the seasonal success pattern of party boat anglers, the charter boat fishing season was slow until late May and early June when bluefish began to appear. Charter boat catches, however, declined again when bluefish emigrated in the fall. Catches picked up for a short while in December when Atlantic mackerel and silver and red hakes began showing up in the landings. The relatively poor season for the charter boat fleet was reflected in their catch statistics (Table 7); they caught only 2 percent of the total catch by New York Bight boat fishermen in 1971.

Private boat anglers caught 62 percent of their catch while surface fishing. As with party and charter boats, bluefish (55 percent) or Atlantic mackerel (28 percent) dominated the catch by private boat anglers, however, their catch of other species was more numerous (Table 8). Most of the oceanic species, such as little tunny, bluefin tuna, skipjack tuna, *Euthynnus pelamis*; and Atlantic bonito were caught by private boat anglers, as were 94 percent of all striped bass. Summer flounder constituted 51 percent of their catch while bottom fishing. Silver hake were the next most numerous species taken, with peak landings during May. Tautog landings peaked during October. Scup, red hake, black sea bass, and Atlantic cod were caught sporadically throughout the year while bottom fishing.

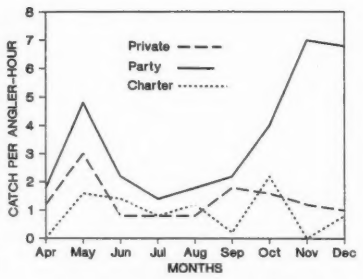


Figure 3.—Catch per angler-hour by charter, party, and private boat fishermen while surface fishing, April through December 1971.

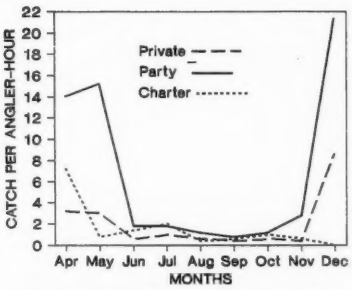


Figure 4.—Catch per angler-hour by charter, party, and private boat fishermen while bottom fishing, April through December 1971.

Catch Rates

Catch per angler-hour fluctuated considerably during the season and among the three fishing groups (Figs. 3, 4). In general, the highest monthly catch rates occurred during the spring, late fall, and early winter when Atlantic mackerel dominated the catch. The lowest monthly catch rates occurred in the summer and early fall.

Party boats had consistently higher monthly catch rates for pelagic species than either private or charter boats, except during July when their monthly catch rate was slightly lower than that of charter boats (Fig. 3). Their catch rates were high during spring when the fishery was harvesting large numbers of Atlantic mackerel from the northernly migrating schools until they passed beyond the daily range of most boats in June. They were replaced in early summer by schools of bluefish entering the area from the south and offshore. This resulted in a sharp drop in the monthly catch rate from 15.3 fish per angler-hour in May to less than 2.0 fish per angler-hour in June. Between June and October, bluefish dominated the surface fishery and the monthly catch rates remained below 2.0 fish angler-hour. After the bluefish departed in November, the monthly catch rate increased again in December when Atlantic mackerel returned during their fall migration south. We found the party boat captains we interviewed had spent 6,243 angler-hours night fishing during which 13,058 fish were caught (Table 9). Bluefish represented over 95 percent of that catch.

We were not able to estimate total night fishing angler-hours or total catch; we did, however, estimate monthly catch rates which varied between 1.1 and 2.4 fish per angler-hour. The average number of fish caught per angler-hour while night fishing tended to be slightly higher than the number caught during daylight hours. As expected, the night fishing catch rates basically followed the same trend as established by daytime surface fishing from party boats, except during September when the night fishing, monthly catch rate indicated a slight increase.

Party boat anglers had consistently higher bottom fishing monthly catch rates than private or charter boat anglers (Fig. 4). Their highest catch rates occurred during May and December when red and silver hake dominated the landings, and during October and November when scup entered the landings in large numbers. Their lowest catch rates occurred during the summer when summer flounder and red hake dominated the landings.

Charter boat fishermen seeking pelagic species had their highest monthly catch rates during April and July (Fig. 3). Only during April, when Atlantic mackerel dominated the landings, did the monthly catch rate exceed 2.0 fish per angler-hour. During May, when bluefish began to replace Atlantic mackerel as the most prevalent species, the monthly catch rate dropped below 2.0 fish per angler-hour from a seasonal high of 7.2 fish per angler-hour during April. For the remainder of the season, bluefish represented most of the pelagic catch. Charter boat anglers had low monthly catch rates while seeking

Table 9.—Night fishing statistics for party boat fishermen interviewed from June through October, 1971.

Item	June	July	Aug.	Sept.	Oct.
Angler-hours	2,322	1,980	904	637	400
Catch (no. of fish caught)	5,620	4,656	1,006	1,036	740
Catch per angler-hour	2.4	2.4	1.1	1.6	1.8

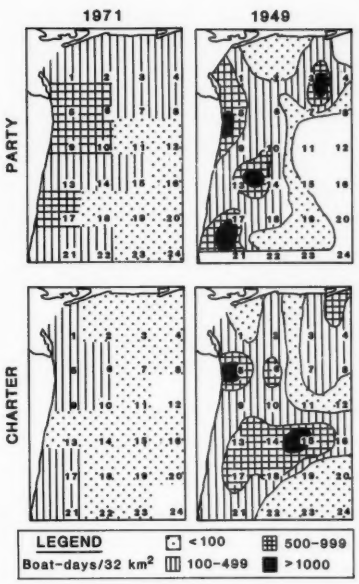


Figure 5.—Boat-days per 32 km² (20 mi.²) for party and charter boats during 1949 and 1971. Original data from 1949 presented only as contours. Effort data from 1971 presented by sectors (see Fig. 1).

demersal species, only once exceeding 2.0 fish per angler-hour (Fig. 4). Their highest catch rates occurred during May and June when red hake made up most of the catch, and during October when scup was the predominant species.

The highest monthly catch rates for the private boat surface fishery occurred during spring and winter when Atlantic mackerel dominated the catch and their lowest catch rates occurred during summer when bluefish were sought (Fig. 3). In general, they had lower monthly catch rates than either charter or party boat anglers. Only during May was their catch rate higher than that by charter boat anglers. The difference in these catch rates may be due to private boat anglers fishing primarily for Atlantic mackerel during May which normally yielded high catch rates, while charter boat anglers sought bluefish which normally yielded comparatively low catch rates. The highest monthly catch rate (3.0 fish per angler-hour) for private boats bottom fishing occurred during May, the other monthly catch rates fluctuated between 0.7 fish per angler-hour and 1.7 per angler-hour (Fig. 4).

Table 10.—Estimated number (in thousands) and percent total of each species caught by party and charter boat fishermen in the New York Bight apex, April through December 1949 (Redfield and Walford, 1951).

Species	Boat type: Party No.	Party %	Charter No.	Charter %	Total for 1949 season
Scup	3,161	45.5	126	8.1	3,287
Atlantic mackerel	1,985	28.6	1,047	67.0	3,032
Black sea bass	1,032	13.0	73	4.7	1,105
Red hake	208	3.0	4	0.3	212
Summer flounder	186	2.7	24	1.5	210
Tautog	146	2.1	6	0.4	152
Bluefish	4	<0.1	136	8.7	140
Weakfish	78	1.1	15	1.0	93
Atlantic cod	66	0.9	12	0.8	78
Little tunny	1	<0.1	46	2.9	47
Bluefin tuna	0	0.0	24	1.5	24
Dolphin	2	<0.1	12	0.8	14
Skipjack tuna	0	0.0	6	0.4	6
Atlantic bonito	0	0.0	3	0.2	3
Striped bass	0	0.0	1	0.1	1
Others	74	1.0	27	1.7	101

Discussion

Historical Comparisons of Effort and Catch Rates

Although several previous surveys have been conducted of the New York Bight recreational fishery, only Redfield and Walford (1951) estimated total effort and catch by party and charter boat anglers. They presented their effort data in contours of boat-days per 32 km² (20 square miles) per year. For comparison purposes, we converted our effort estimates to the same units, but could only present them for sectors as our sampling and summarizing methods prevented us from drawing contours (Fig. 5) similar to those of Redfield and Walford (1951).

Although the number of party boats fishing the survey area decreased from 157 (in 1949) to 122 (in 1971), the distribution of effort changed very little (Fig. 5). Party boat anglers in 1949 concentrated much of their effort, 1,000+ boat-days per 32 km², in sectors 7, 9, 14, and 21 (Fig. 5). The remaining effort was distributed within 24 km of the coast. Party boats still concentrated much of their effort nearshore in 1971, but extended the remainder further offshore than in 1949, possibly a partial reflection of an increase in the size and speed of party boats or greater competition for resources. They decreased their fishing intensity in sectors 7 (the sewage sludge area) and 14 (Fig. 5), while maintaining their 1949 intensity in coastal sectors 5, 9, 17, and 21 and increasing it to 1,000+ boat-days per 32 km² in sectors 6 and 10 (the Christiensen Basin and Mud Hole).

In 1949, charter boat anglers concentrated much of their effort in sectors 5 and 15 and scattered the remainder throughout the survey area (Fig. 5). In 1971, their fishing intensity decreased in nearly two-thirds of the sectors, but not in sectors 6, 9-11, 21, and 23 (Fig. 5). Most of the fishing effort in 1949 seemed to be directed further offshore than in 1971, possibly more effort for large pelagics, e.g. tunas.

Our estimate of catch is not directly comparable to that of Redfield and Walford (1951) because of differences in our survey boundaries. We estimated catch only within our survey area by the party and charter boat fleet sailing from ports between Manasquan Inlet and Jones Inlet, whereas Redfield and Walford (1951) estimated the entire catch by the fleet, overlooking boundaries. Overall catch composition, however, should be comparable since the majority of the effort by the fleet in 1949, as in 1971, was within our survey boundaries.

The catch composition by fishermen aboard party boats in 1971 differed from that reported in 1949. Scup, Atlantic mackerel, and black sea bass were the most numerous species taken in 1949, representing 87.1 percent of the catch (Table 10). In 1971, proportional to 1949, the percentage of scup in the catch was lower by 40.2 percent while Atlantic mackerel was higher by 37.5 percent to become the largest component of the total catch. Red and silver hake were the second and third most numerous species caught in 1971, representing 9.3 and 7.1 percent, respectively, of the catch. In 1949, red hake constituted 3.0 percent of the catch, while silver hake were not mentioned.

The charter boat catch composition in 1971 differed from that in 1949. Com-

Table 11.—Estimated catch per man-day for major species during selected years for party and charter boats.

Species	Party boats 1948[1]	1949[1]	1952[1]	1971[1]
Atlantic mackerel	30.0	26.0	33.6	69.2
Scup	19.8	32.2	31.1	31.8
Black sea bass	12.9	17.0	14.9	2.4
Summer flounder	11.6	7.6	7.3	3.0
Weakfish	19.1	18.5		4.3

	Charter boats 1938[2]	1941[2]	1948[1]	1949[1]	1971[1]
Atlantic mackerel			25.1	33.0	20.3
Bluefish			5.7	6.0	7.5
Little tunny			2.3	3.6	2.8
Bluefin tuna	1.6	1.2	1.1	4.2	1.4
Striped bass			0.9		2.2

[1]Catch rate calculated from trips in which a species represented 75 percent or more of total catch. The 1948 estimates are from Butler and Spear (1950), 1949 estimates are from Redfield and Walford (1951), and 1952 estimates are from Younger and Hamer (1952).
[2]Catch rates calculated from trips in which the fisherman stated that he was fishing specifically for a given species and original data presented as fish per boat-day trip. We assumed an average of six fishermen per boat. The 1938 estimates are from Westman (1938) and 1941 estimates are from Westman and Neville (1942).

pared to 1949, the relative abundance of Atlantic mackerel, scup and black sea bass in 1971 were lower, while bluefish, red hake, summer flounder, tautog, and striped bass were higher. The catch of bluefish (dominant species in 1971) was higher by 47.3 percent and Atlantic mackerel (dominant species in 1949) was lower by 58.6 percent.

Between 1948-52 and 1971, party boat anglers have experienced higher catch per angler-day for Atlantic mackerel and lower catch rates for black sea bass, summer flounder, and weakfish (Table 11). For summer flounder, this lowered catch rate appears to have stabilized as Christensen and Clifford (1979a) report a catch rate of 3.2 fish per angler-day for 1978 party boat data in the same general area. Between 1948 and 1952, Atlantic mackerel catch rates fluctuated by only 8 fish per angler-day, but were doubled in 1971. Scup catch rates showed a sharp increase from 1948 to 1949, but thereafter the rate was similar in 1952 and 1971. Black sea bass catch rates also showed a slight increase between 1948 and 1949, but was lower in 1952 and only 2.4 fish per angler-day in 1971.

Charter boat anglers did not experience wide fluctuations in catch per angler-day as did party boatmen. Catch rates in 1971 for Atlantic mackerel, little tunny, and bluefin tuna were about the same as those in 1948, but lower than those in 1949. Bluefin tuna and striped bass catch rates are higher in 1971 than in 1948.

The proportional participation of charter, party, and private boats in the New York Bight apex recreational fishery seems to have changed between 1949 and 1971. Charter boats no longer share the position, with party boats, in 1971 of being the primary type of boat used by recreational fishermen, but may have relinquished their position to private boats. This must be inferred, in the absence of prior specific effort data, by an overall decrease in the carrying capacity of the charter boat fleet and an increase in the carrying capacity of the party boat fleet. Between 1949 and 1971, the charter boat fleet decreased by about 190 boats, while the average boat capacity remained the same. The number of party boats available to fishermen also decreased (slightly), but the carrying capacity of the fleet (size of vessels) increased from 30 to 50 fishermen per average boat, thereby increasing the overall party boat fleet's daily carrying capacity by nearly 2,000 fishermen in 1971. In discussing this possible trend we are making the reasonable assumption that the number of boats in the fishery is a relatively conservative variable and does not have major year-to-year fluctuations.

We were not able to estimate changes in private boat useage because of the lack of prior effort data. An increase in effort, however, does seem likely because of technological advances in small boats (5-10 m). Improvements in relatively inexpensive small boat production techniques, designs, and materials, and general standard of living made it possible for more fishermen to buy and operate their own boats and to fish many areas previously fished exclusively by charter and party boats.

The importance of the party boat fleet to the recreational fishery is reflected in our effort statistics. During 1971, party boat fishermen expended more angler-hours than private or charter boat fishermen. They were responsible for over half of the total effort, two-thirds of the total bottom fishing effort, and two-fifths of the total surface fishing effort. Charter boats accounted for less than 10 percent of the total effort. Private and charter boat fishermen spent nearly 65 percent of their effort seeking pelagic species while party boat fishermen divided their time about equally between pelagic and demersal species.

Distribution of effort by party boat fishermen has changed little between 1949 and 1971 surveys. Most of their angler-hours were expended within 16 km (10 miles) of the New York and New Jersey coasts. There was, however, a suggested slight decrease in effort in the northeastern sectors of the survey area and a corresponding increase in effort in the western sectors. The distribution of effort by charter boat fishermen between 1949 and 1971 changed more noticeably than that by party boat anglers. In 1949, charter boats scattered their effort throughout the survey area, whereas in 1971 they concentrated most of it within 16 km (10 miles) of the New Jersey coast.

Magnitude of the 1971 Apex Recreational Fishery

Our data suggest that the New York Bight apex supports a major, concentrated recreational fishery that harvested about 7.6 million game fish in 1971 (Table 5). This may be >10 percent of the mean combined total New York/New Jersey marine recreational catch based on a 71.7 million fish average for the period 1979 through 1984 (USDOC, 1984, 1985a,b). The 10 percent estimate is minimal as the Commerce Department data include nonboat data and estuarine data and we did not include nongame fish in our estimates. Marine recreation fish catches in the New York/New Jersey waters vary annually. For example, the Commerce Department's Marine Recreational Fishery Statistics Survey data for 1979 through 1984 (USDOC, 1984, 1985a,b) estimates the total annual, combined New Jersey and New York recreational catch ranged from a low of about 40 million fish (1982) to a high of about 100 million fish (1980).

Our 1971 catch estimate is not direct-

ly comparable to commercial landings records because of the lack of weight data. McHugh (1977) concluded from an analysis of New Jersey and New York commercial landing records and recreational surveys, however, that the recreational catch (by weight) of several commercially important species during the 1960-70 decade was larger than the domestic commercial catch. This could be due to an extremely complex situation stemming from sociopolitical and economic factors along with an increase in the number of recreational fishermen.

Surface fishing in 1971 was mostly dependent on two migratory pelagic species: Atlantic mackerel during spring and early winter and bluefish during summer. The popularity of bluefish and Atlantic mackerel varied among the vessel types which is probably a reflection of seasonal availability of the two species and seasonal distribution of fishing effort by the different vessels. Party boat anglers expended nearly one-third of their 1971 surface fishing effort in pursuit of Atlantic mackerel; charter and private boat anglers directed less than 10 percent of their surface fishing effort toward Atlantic mackerel. This resulted in Atlantic mackerel composing nearly 60 percent of the total 1971 catch. Deuel (1973) also found Atlantic mackerel to be the single most numerous fish caught by party-charter boats off the northeastern U.S. in 1960's.

Bluefish was the most highly sought pelagic species in the New York Bight apex in 1971, based on the Butler and Spear (1950) assumption discussed previously. More angler-hours were spent seeking bluefish than any other species including a specific party-boat night fishery. Even though the total number of bluefish caught in 1971 was less than the catch of Atlantic mackerel, we believe the total pounds to be much larger because of the larger average size of bluefish. Deuel (1973) found this to be generally true of the overall recreational catch between Maine and Cape Hatteras, N.C. In terms of pounds landed, the recreational fishery for bluefish was much larger than the commercial fishery in the Bight (McHugh, 1972, 1977). The popularity of bluefish to fishermen stems to a large degree from bluefish being abundant in the Bight during favorable weather conditions when all types and sizes of vessels can participate in the fishery, as well as, the species' larger size and fighting nature.

Historical Comparison of Catch Composition

The importance of Atlantic mackerel and bluefish to party and charter boat anglers seems to have changed, in most cases, between 1949 and 1971. Between these two survey periods, the percent composition of Atlantic mackerel in the party boat catch increased by 37 percent and bluefish by 6 percent (probably not significant). Whereas the two species seem to have exchanged relative position with charter boats, e.g., the relative number of Atlantic mackerel decreased by 63 percent while bluefish increased by 47 percent. Catch figures from the National Saltwater Angling Surveys for 1960, 1965, and 1970 (Clark, 1962; Deuel and Clark, 1968; Deuel, 1973) also indicate changes in the relative numbers of these species. The total recreational catch of bluefish from Maine to Cape Hatteras between 1960 and 1970 increased only slightly (0.3 percent), while Atlantic mackerel increased by 13.1 percent. McHugh (1972, 1977) also reported a resurgence in the commercial fishery for bluefish, although there was much year to year variability, in the Bight. Atlantic mackerel commercial landings were strong in 1949 but less in the 1960's, increasing again in the 1970's. Effort and abundance is involved, however, in these trends (Long and Figley, 1982) and is probably reflected in the overall increase of Atlantic mackerel landings in the recreational and commercial fisheries, despite a decrease in the charter boat fishery. The change in the relative number of Atlantic mackerel and bluefish in the charter boat catch may merely be a reflection of fishermen preference for one species over the other.

Increased bluefish landings in 1971 and more recent years may be due to increased abundance. Historically, bluefish abundance is known to vary between years but generally being a major hook and line species as far back as the 1880's (Smith, 1892). Whether increased landings are due to increased abundance or increased availability due to environmental conditions is unknown (McHugh, 1977). The party boat night fishery for bluefish, that probably developed since the 1950's, is another plausible reason for the increase. Christensen and Cliffort (1979b) estimate the night harvest of bluefish from party boats "greatly exceeds the day catch within the study area". Their study area was also, for the most part, the apex. This night fishery also had better results for a few other species as well, including several species of sharks.

The bottom fishery is dependent on a greater variety of species than the surface fishery. Hakes, scup, and summer flounder represented most of the demersal fishes landed, however, the relative importance varied among the vessel types. Silver hake, red hake, and scup were the most numerous species caught by party boat anglers, whereas, both hakes represented the greatest portion of demersal fishes caught by charter boat fishermen. Private boat fishermen caught few hakes and scup, but more summer flounder than party and charter boats combined. Christensen and Clifford (1979a) note that party boats, at least, fish for summer flounder mostly in late spring/early summer but then shift to bluefish when they move into the area and continue to fish for them up to December.

McHugh (1972) points out that the commercial fishery in the Bight has been able to maintain landings by switching from a group of fishes of declining abundance to one of abundance. This is also probably the case with the recreational fishery. For example, during 1949, scup and black sea bass were the most numerous demersal species caught by the party-charter fleet and hakes one of the least numerous, representing 45.5, 13, and 3 percent, respectively, of the total catch (Table 10). In 1971, the representation of scup and black sea bass in the total catch was only 5 percent and 1 percent, respectively, and hakes increased to 16 percent (Table 5). Recreational landings are greatly influenced by the desires or demands of the sportsman which may explain the change in percentage composition of

Atlantic mackerel and bluefish in the charter boat landings.

Other broadscale surveys have reported similar declines in scup and black sea bass landings. Deuel and Clark (1968) and Deuel (1973) noted declines from 1960 to 1970 in the Middle Atlantic recreational fishery. Black sea bass, which has supported a notable fishery since colonial times in the area (Smith, 1892; Pearson, 1972), declined from 19 percent of the total catch to 3 percent and scup declined from 20 to 2 percent. Scup landings from the New York commercial fishery have been declining since 1958 and black sea bass since 1952 (McHugh, 1972). New Jersey landings have also declined, but not as drastic as the New York landings (McHugh, 1977). The decline in scup landings may have been due to a year class failure or overfishing (Briggs, 1968; McHugh, 1972) or a combination of the two. This may have been a temporary fluctuation in the stock size since scup stocks historically are known to vary, perhaps in cycles (Finkelstein, 1969). Our catch-per-unit-effort data indicate that the scup stock may have increased since the average catch per angler-day in 1971 was similar to that in 1949 and 1952 when large landings were made. The small landings of scup in 1971 may be the result of reduced fishing effort being directed specifically for them. McHugh's (1977) summarized New Jersey commercial landings indicated a marked increase in scup landings since 1970 which may represent an increase in abundance or availability or increase in an offshore winter fishery. The difference in black sea bass catch rates in the recreational fishery between 1949 and 1971 suggests the possibility of declining abundance.

The percentage composition of the bottom fishing catch differed among the three types of vessels. This difference is probably attributed to a disproportional amount of fishing effort being directed specifically toward a species or group of species. For example, private boat anglers probably caught a higher percentage of summer flounder and striped bass than party and charter boat anglers because they probably directed a higher percentage of their effort toward these species. The same can be said for the high percentage of scup and hakes in the party and charter boat landings.

Artificial habitat was important to the bottom fishery since it provided additional habitat for fishes normally associated with rocky substrate. These sites were fished by all types of boat anglers (Table 4). Party boat anglers, however, spent a greater relative number of angler-hours over them than did either charter or private boat angler. These results and conclusions are consistent with a study the previous year, 1970, of the same general area (Stone et al., 1974). The difference in effort by party and private boat anglers may be due to the inability of the latter to locate wrecks; many private boat anglers lacked the necessary knowledge of the area and electronic sounding equipment. Whereas, most party boat captains have land ranges or electronic equipment for locating many of these productive sites. Charter boat anglers and many private boat anglers may not have fished much over artificial habitat because a greater desire for nonreef dwelling species, such as silver hake or summer flounder.

We were not able to compare catch composition and angler success among the different habitat types because our sample was too small and the fishing effort was not distributed among all months. In general, Stone et al. (1974) found artificial habitat to provide party boat anglers in the Bight with catch rates higher than those over sandy or mud bottoms. They did not find this to be true for private anglers. The difference in angler success is probably due to the fisherman's ability to locate the exact position of the artificial habitat. From our experience, we found it necessary to fish in close proximity to an artificial habitat to reap the benefits.

Artificial habitat did not appear to be important to the fishermen seeking pelagic fishes. A relatively small amount of surface effort was spent over artificial habitat. This may have been due to possible low catch rates, although we were unable to estimate these rates, as stated earlier. Low surface fishing success was found for fishermen in the Bight during 1970 (Stone et al., 1974); and for fishermen off Murrells Inlet, S.C. (Buchanan et al., 1974).

Although the survey area includes several waste dumping sites and managers are interested in documenting effects, the present survey was not designed to address this question of effects of waste disposal on the apex recreational fishery and it would be very difficult to use the information presented here for this purpose, in hindsight. The reason for this caution is that the waste disposal areas are small portions of the data collection summarization sectors (sewage sludge area is <25 percent of sector 7) or bracket two sectors (dredge spoils are included in sectors 6 and 10) although sector 6 mostly contains the highly contaminated Christiensen Basin. So although there is a suggestion, in the 1971 summarized data (Fig. 2), that: 1) Party boats spent considerable effort (15-20 percent) fishing for pelagic species in sector 7 containing the sewage sludge disposal area; 2) charter boats spent substantial effort (>15 percent) bottom fishing in the Christiensen Basin (sector 6) and Mud Hole (sector 10); and 3) party and private boats spent little time bottom fishing in the same areas and sector 7, these patterns cannot be reasonably associated with waste disposal from the available data. The same is true in attempting to compare the 1971 data to historical data (Fig. 5) as there are too many undefined or unmeasured variables to state or suggest that any of the use patterns of 1971 or 1949 involves a response to waste disposal.

Other survey data, e.g., Long and Figley (1982), are also vague in describing relationships of fisheries to waste disposal practices, with several recreation fishing grounds, e.g. for Atlantic mackerel, various species of tuna, bluefish, silver hake, black sea bass, and tautog, as well as commercial fisheries for some of the same species and lobster being generally defined to include the disposal areas.

Although historical data are insufficient to define impacts of some waste disposal practices, other waste disposal practices in the Bight apex may actually have created fishing grounds. Westman[1] discusses how the dumping of

building rubble off Long Beach, New York in 1949 created "the McAllister Grounds", a type of artificial reef, and the disposal of rocks in the Christiensen Basin from subway excavation under New York City created the "Subway Rocks" ground near Ambrose Light. Westman also reports that when the disposal of acid wastes begun on the Cholera Bank in 1950, the yellow, iron stained waters became a prime bluefishing grounds through the 1950's, although less so later on. Again, the lack of quantitative data reduces the confidence in these reports.

In summary, we have presented a fairly detailed picture of the recreational fishery by party, charter, and private boats in the New York Bight during 1971. It supports the growing recognition of the importance of a relatively intensive recreational fishery in this area, an area under high multiple use pressure and establishes a baseline for future evaluation of fishery changes.

Acknowledgments

This paper was improved by the suggestions of Stuart Wilk, Daryll Christensen, Chester Zawacki, Philip Briggs, Tom Morrissey, Ron Essig, and others. Also special thanks go to the many party and charterboat captains who maintained our logs, to the sport fishermen who took the time to accurately complete our questionnaire, and to Michelle Cox for preparing the figures. This paper is dedicated to the late Lionel A. Walford who devoted his life to bringing scientific management to marine recreational fisheries, and who was a guiding light for at least a generation of fishery scientists.

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The Commercial Bait Shrimp Fishery in Galveston Bay, Texas, 1959-87

KENNETH N. BAXTER, CARLTON H. FURR, Jr., and ELIZABETH SCOTT

Introduction

Live and dead shrimp are a preferred natural bait for recreational fishing. As a result, extensive bait-shrimp fisheries have developed along the Gulf coast, especially in Florida and Texas (De Sylva, 1954; Woodburn et al., 1957; Chin, 1960; Saloman, 1965; Inglis and Chin, 1966; Berry and Baxter, 1969). In 1984, the estimated market yield for bait shrimp landed from the Galveston Bay System was $4.3 million. Both inshore and offshore fishermen exploit the same shrimp population, though at different stages of the life cycle. The bait catch, if large enough, could depress the subsequent "table" shrimp catch.

Long-term statistical information pertaining to bait shrimp production along the Gulf of Mexico and Southeast Atlantic is collected in only two states, Florida and Texas. The Florida Department of Natural Resources (formerly, the Florida State Board of Conservation) collects routine production statistics from bait-shrimp fishermen operating in that state (Joyce, 1965; Jones and Smith, 1966). Since 1985, they have incorporated the Marine Fisheries Trip Ticket program, a dock receipt system, which provides production statistics as well as fishing location and effort data[1].

The longest, continuous systematic survey of bait shrimp fishery operations is conducted by the National Marine Fisheries Service (NMFS) in Galveston Bay, Tex. This survey was an outgrowth of the shrimp research program of the Bureau of Commercial Fisheries (now NMFS) which began in the late 1950's. Surveys of the bait shrimp fishery of Galveston Bay began in 1957. Background information, including data on landings and species composition, was reported by Chin (1960). These surveys provide detailed measures of relative abundance and species composition of juvenile and subadult shrimp in the study area. The statistics provide a check on the validity and effectiveness of the NMFS index of postlarval shrimp abundance obtained by sampling at the entrance to Galveston Bay (Baxter, 1963).

As an outgrowth of the average weekly catch per unit effort (CPUE) data collected from the Galveston Bay bait shrimp fishery during late April through early June, the bait index was developed (Baxter, 1963; Berry and Baxter, 1969; Caillouet and Baxter, 1973; Baxter and Sullivan, 1986; Klima et al., 1982-87). A regression model (Fig. 1) derived from the bait index versus subsequent offshore production from 1960 through 1986 ($r^2 = 0.826$) is used to predict the annual offshore Texas brown shrimp catches (Table 1).

Additionally, these indices of postlarval and juvenile shrimp abundance provide valuable comparisons for long-term assessment of the relation between abundance and changing environmental conditions and specific information concerning local fishing practices and trends for 1959 through 1987. Summaries of the survey results including catch, effort, species composition, and

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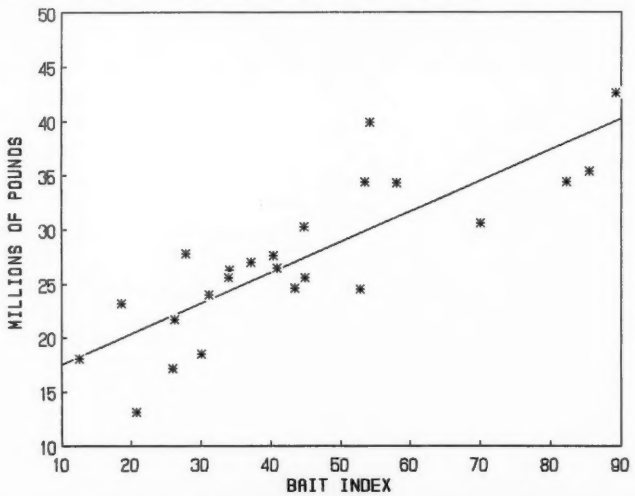

Figure 1.—Galveston Bay bait index versus Texas offshore actual catch, 1960-1986.

[1]Kennedy, S. 1987. Florida Department of Natural Resources, St. Petersburg. Personal commun.

Table 1.—Galveston Bay bait shrimp index values from 1960 to 1987 used to predict annual (July-June) Texas offshore brown shrimp catches (Klima et al., 1987).

Year	Bait index	Catch data (millions of pounds Predicted catch	Actual catch	Difference in catch
1960	53.6	29.1	34.5	+5.4
1961	20.8	20.0	13.2	-6.8
1962	26.1	21.5	17.3	-4.2
1963	53.0	29.0	24.6	-4.4
1964	30.2	22.6	18.6	-3.9
1965	41.0	25.6	26.4	+0.9
1966			31.5	
1967	89.4	39.0	42.7	+3.7
1968	28.0	22.0	27.9	+5.9
1969	43.5	26.3	24.7	-1.6
1970	70.0	33.7	30.7	-3.0
1971	82.3	37.1	34.4	-2.6
1972	85.6	38.0	35.5	-2.5
1973	18.7	19.4	23.3	+3.9
1974	34.3	23.8	26.4	+2.6
1975			23.7	
1976	34.2	23.8	25.7	+1.9
1977	58.5	30.5	34.4	+3.9
1978	40.5	25.5	27.7	+2.2
1979			16.5	
1980	45.0	26.7	25.7	-1.0
1981	54.3	29.3	40.0	+10.7
1982	26.3	21.5	21.8	+0.3
1983	12.7	17.8	18.2	+0.4
1984	31.2	22.9	24.1	+1.2
1985	44.9[1]	29.0	30.4	+1.4
1986	37.2	25.3	24.4[2]	-0.9
1987	38.6	25.7	NA	NA

[1]Modified bait index model used.
[2]Preliminary data.

Figure 2.—The Galveston Bay system showing location and number of bait shrimp dealers in 1987.

Table 2.—Number of bay shrimp licenses sold by the State of Texas, 1960-87.

Year	Individual bait shrimp trawl	Commercial bay bait trawl	Commercial bay shrimp boat	Commercial bait shrimp boat
1960	8,837	1,846		
1961	7,399	2,506		
1962	6,249	2,456		
1963	7,003	3,228	24	5
1964	6,367		1,849	1,196
1965	7,034		2,217	1,321
1966	7,144		1,969	1,460
1967	7,324		1,760	1,752
1968	7,508		1,953	632
1969	8,553		2,457	768
1970	9,662		3,218	881
1971	9,947		3,743	966
1972	9,296		3,995	1,265
1973	9,537		3,974	1,365
1974	10,521		3,747	1,590
1975	9,281		3,523	1,368
1976	8,866		2,917	1,406
1977	9,707		3,232	1,449
1978	9,982		3,768	1,521
1979	10,349		4,444	1,752
1980	8,925		4,473	2,016
1981	8,729		5,215	2,217
1982	7,433		4,479	2,283
1983	6,921		4,711	2,723
1984	5,339		4,922	3,103
1985	4,547		4,387	2,396
1986	4,147		3,613	2,680
1987	3,597		3,402	2,527

numbers of active dealers and fishermen are prepared monthly (1959-84, except 1975, partial 1985-87) and are available to the public. These data serve an important role as guidelines for making management suggestions and provide background for continuing research on this natural resource.

Scope of the Fishery

The Galveston Bay System, covering some 336,000 surface acres (135,979 ha), averages 14 miles (22.5 km) long, 8 miles (12.9 km) wide, and about 5 feet (1.5 m) deep. For reporting purposes, this area has been divided into West Bay, Lower Galveston Bay, Upper Galveston Bay, Trinity Bay, East Bay, and major back-bay areas such as Chocolate Bayou, Dickinson Bayou, Moses Lake, and Clear Lake (Fig. 2).

Chin (1960) reported that about 200 bait dealers operated in this area at the time of his survey in November 1956. That number remained fairly constant until Hurricane Carla struck the Galveston area on 9 September 1961 and severely damaged the bait-shrimp facilities of Galveston Bay. Many bait establishments were completely destroyed due to the hurricane and many were not rebuilt. After 1961, the number of bait facilities gradually increased until Hurricane Alicia struck on 17 August 1983. An assessment made 9 September 1983, revealed that of about 90 bait camps in the Galveston Bay area, 31 percent were destroyed, 42 percent were damaged and/or closed, and 27 percent were open with little or no damage. The number of bait dealers now operating is near 70.

Commercial bait dealers operate their own vessels or are supplied by commercial fishermen (or both). The number of bay-bait shrimp trawlers, as reflected by Texas Parks and Wildlife Department (TPWD) license sales (Hamilton, 1983), ranged from 1,846 in 1960 to 3,228 in 1963 (Table 2). Near the end of 1963, however, separate licenses were

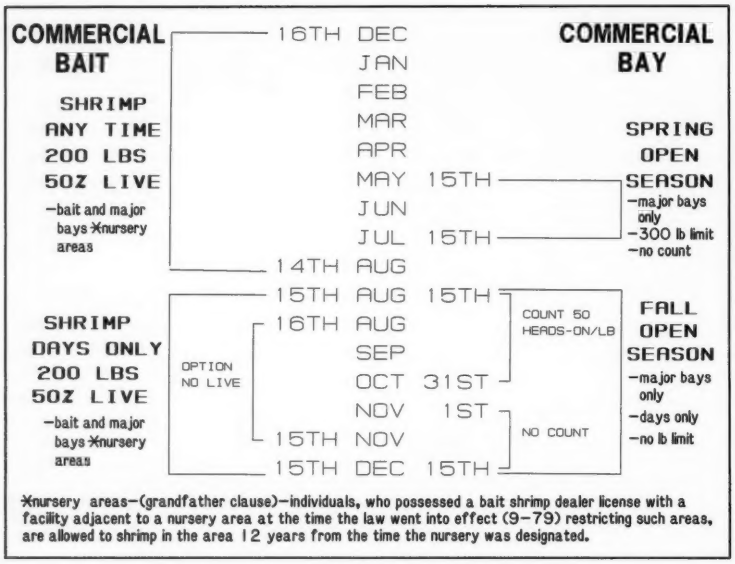

Figure 3.—Commercial bait and bay regulations, 1987.

required of commercial bait and commercial bay shrimp fishermen. Current TPWD commercial regulations require both an individual bait shrimp trawl license and a sport license for persons taking shrimp for personal use only, a commercial bay boat license for persons taking shrimp for pay or sale from major bays, and a commercial bait-boat license for those taking bait shrimp for pay or sale in bay waters (Krauthamer et al., 1984; TPWD, 1987). One person may possess a commercial bay and a commercial bait license; however, different restrictions apply (Fig. 3).

The sharp drop in commercial bait shrimp boat license sales in 1968 (Table 2) was due to a law change in 1967 regulating the holding of live shrimp. The law stipulated that bait fishermen must have aboard their boats a tank or box capable of holding and keeping alive at least 50 percent of the shrimp catch. On 31 August 1981, however, this law was revised: The catch limit for bait shrimp was raised from 150 to 200 pounds per day with no requirement to maintain 50 percent alive from 16 August through 15 November (TPWD, 1981). It appears that commercial bait license sales increased annually from 1968 to a maximum in 1984 (Table 2). Collectively, since 1985, license sales have been declining. This decrease may be attributed to one or more of the following:

1) A reduction in "part-timers" purchasing commercial shrimp licenses[2,3]. Part-timers are categorized as individuals who typically own a small boat (<25 feet) and shrimp weekends and/or vacations, especially during the white shrimp or fall open season[3]. In 1985 the price of commercial bait and bay licenses jumped from $60 to $80. This price increase, coupled with the depressed Texas economy, possibly discouraged individuals from renewing commercial licenses.

2) High inshore salinities and low white shrimp production in recent years.

3) Materials for boat construction and/or maintenance and operational costs for existing boats exceed profits[3].

[2]Bryan, C. E. 1988. Texas Parks and Wildlife Department, Austin, Personal commun.

[3]Standley, C. L. 1988. President, Professional Involvement of Seafood Concerned Enterprises (P.I.S.C.E.S.), Galveston, Tex. Personal commun.

Shrimp Fauna

The Galveston Bay system serves as a nursery area for several commercially important species of penaeid shrimp. The bait shrimp fishery depends primarily on white shrimp, *Penaeus setiferus*, and brown shrimp, *P. aztecus*. Other species taken infrequently in the catch include pink shrimp, *P. duorarum*; broken neck shrimp, *Trachypenaeus similis*; seabob, *Xiphopenaeus kroyeri*; rock shrimp, *Sicyonia dorsalis*; grass shrimp, *Palaemonetes* sp.; and river shrimp, *Macrobrachium* sp. The combined catch of these latter species, however, did not exceed 3 percent of the total annual catch in any year of this study (Table 3). Of the two major species involved, brown shrimp are the dominant species from May through July (Fig. 4) while white shrimp dominate the catch from August through April (Chin, 1960; Inglis and Chin, 1966; Trent, 1966; Baxter and Renfro, 1967; Pullen and Trent, 1969; Parker, 1970; Lampkin, 1984).

The species composition of bait shrimp catches varies from bay to bay along the Texas coast (Baxter, 1966). Bait shrimp catches from Galveston Bay are predominately white and brown shrimp throughout the year, while those from Aransas Bay and Laguna Madre show a high incidence of pink shrimp (Table 4). These figures do not necessarily reflect the relative abundance of the three species of shrimp, however, since each spends a different proportion of its life in estuarine waters.

Vessels, Fishing Gear, and Holding Equipment

The otter or shrimp trawl was first introduced in 1912 (Anderson et al., 1949). Over the years, Galveston Bay shrimp fishermen have made major changes in their boats and gear. When this survey began in 1959, more than half used outboard motor powered skiffs less than 18 feet (5.5 m) long. Nets usually were retrieved by hand since net size was limited by law to a width of 10 feet (3.0 m) between doors. By 1987, however, over 95 percent of the fisher-

Table 3.—Annual estimated catch (thousand pounds, live and dead), by species in the Galveston bay bait-shrimp fishery, 1959-87. Percentage of annual bait harvest by species, in parenthesis.

Year	Shrimp species: Brown Lb. %	White Lb. %	Pink Lb. %	Other[1] Lb. %	Total Lb.	Percent of total bay landings[2]
1959[3]	88.0 (20)	342.8 (80)		0.2 (<1)	431.0	
1960	384.7 (41)	558.1 (59)		0.6 (<1)	943.4	
1961	427.7 (59)	302.8 (41)	0.3 (<1)	0.4 (<1)	731.2	38
1962	455.9 (43)	606.4 (57)		0.5 (<1)	1,062.8	20
1963	385.5 (39)	606.9 (61)	0.6 (<1)	1.4 (<1)	994.6	22
1964	253.9 (30)	581.2 (69)	10.9 (1)	0.6 (<1)	846.6	14
1965	482.0 (49)	493.9 (50)	5.6 (<1)	3.4 (<1)	984.9	19
1966	375.4 (48)	405.7 (52)	3.4 (<1)	1.4 (<1)	785.9	29
1967	600.9 (55)	483.2 (44)	3.3 (<1)	0.5 (<1)	1,087.9	33
1968	373.7 (34)	726.2 (66)	2.6 (<1)	0.1 (<1)	1,102.6	28
1969	384.3 (38)	622.8 (62)	0.1 (<1)	0.3 (<1)	1,007.5	19
1970	458.4 (46)	544.7 (54)	1.6 (<1)		1,002.7	16
1971	574.3 (49)	605.8 (51)	1.8 (<1)	0.4 (<1)	1,182.3	19
1972	635.2 (51)	605.6 (48)	6.6 (<1)	1.7 (<1)	1,249.1	21
1973	411.7 (37)	679.9 (62)	8.4 (<1)		1,100.0	18
1974	529.8 (45)	655.0 (55)	0.8 (<1)	0.5 (<1)	1,186.1	24
1975[3]	247.9 (82)	55.9 (18)		0.2 (<1)	304.0	
1976	456.8 (47)	502.1 (52)	0.4 (<1)	4.0 (<1)	963.3	16
1977	353.7 (41)	497.7 (58)	1.1 (<1)	0.3 (<1)	852.8	19
1978	399.2 (48)	427.9 (51)	3.4 (<1)	0.4 (<1)	830.9	17
1979	303.8 (53)	267.3 (47)	2.0 (<1)		573.1	15
1980	353.6 (49)	358.4 (50)	1.5 (<1)	1.2 (<1)	714.7	11
1981	463.8 (44)	583.6 (55)	5.1 (<1)	9.5 (<1)	1,062.0	21
1982	414.5 (51)	400.5 (49)	1.5 (<1)	0.4 (<1)	816.9	14
1983	446.5 (64)	250.0 (36)	5.3 (<1)	0.7 (<1)	702.5	14
1984	312.3 (40)	471.8 (60)	0.4 (<1)	0.4 (<1)	784.9	11
1985[3]	180.7 (80)	40.8 (18)	4.6 (2)	0.1 (<1)	226.2	
1986[3]	249.1 (94)	10.5 (4)	4.3 (2)		263.9	
1987[3]	229.9 (90)	23.5 (9)	1.2 (<1)	0.8 (<1)	255.4	

[1]*Trachypenaeus similis*, *Xiphopenaeus kroyeri*, *Sicyonia dorsalis*, and *Macrobrachium* sp.
[2]Percent of shrimp taken from Galveston Bay by bait fishermen; the remaining percentage (100 percent-C) was taken by commercial bay fishermen.
[3]Incomplete data.

Table 4.—Species composition (percent within each bay) of bait shrimp samples from the major bay systems along the Texas Coast (Baxter, 1968).

Year and date	Galveston Bay: Brown	White	Pink	Aransas Bay: Brown	White	Pink	Lower Laguna Madre: Brown	White	Pink
1964									
Aug.	4	96	0	8	91	1	11	46	43
Sept.	9	91	0	8	79	13	3	0	97
Oct.	7	93	0	23	67	10	19	36	45
Nov.	3	96	1	42	33	25	0	1	99
Dec.	1	99	0	2	98	0	1	25	73[1]
1965									
Jan.	0	98	0[1]	5	70	24[1]	3	26	71
Feb.	4	90	1[1]	16	48	28[1]	1	2	96[1]
March	0	98	2	14	36	48[1]	2	1	96[1]
April	4	68	28	1	22	78[1]	17	1	81[1]
May	84	11	5	72	0	28	66	0	34
June	98	1	1	95	0	5	80	0	19[1]
July	73	27	0	8	91	1	89	4	5

[1]Balance composed of *Trachypenaeus* sp., *Xiphopenaeus kroyeri*, *Sicyonia dorsalis*, or *Macrobrachium* sp.

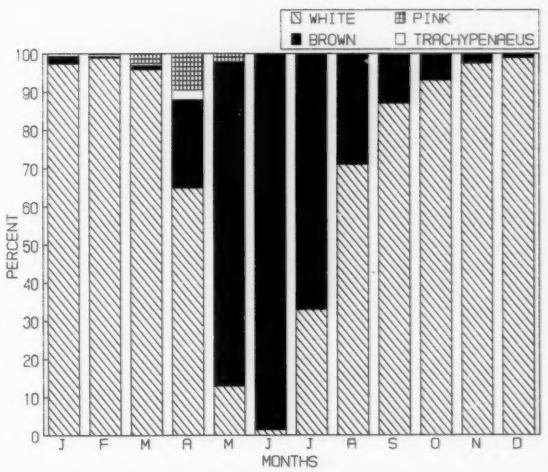

Figure 4.—Average species composition by month (1960-87).

men were using inboard trawlers in the 20- to 45-foot (6.1-13.7 m) class and two nets were in general use: A try net not to exceed 12 feet (3.7 m) and a main net not to exceed 54 feet (16.5 m) as measured from the tip of the door along the corkline to the leading tip of the other door (TPWD, 1987). Variations of the basic otter trawl employed in the Galveston Bay system include box, flat, and semi-balloon net types (Watson et al., 1984; Bessette, 1985). Trawl mesh sizes vary from 1¼ to 2 inches (3.2-5.1 cm) stretched measure. Trawl doors may range from 3 to 10 feet (0.9-3.0 m). Almost without exception, nets are now retrieved by mechanical hoists or winches.

Holding equipment also has been upgraded considerably. During the early days of the fishery, shrimp were simply placed in bait wells or barges alongside the vessel. Due to excessive mortalities resulting from high surface water temperatures, the practice gave way to bait tanks on the decks of catch boats. Bait tanks used on boats are somewhat smaller than those used on land. Tank sizes vary but are generally 3 × 4 × 6 feet (0.9 × 1.2 × 1.8 m). They contain 2-4 compartments and water is circulated through them continuously by gasoline- or electric-powered pumps.

When the catch comes aboard, it is released into the first compartment where unwanted fish, invertebrates, and other matter are culled and discarded. Species of commercial bait value such as striped mullet, *Mugil cephalus*; Atlantic cutlassfish or ribbonfish, *Trichiurus lepturus*; and squid, *Loliguncula brevis*, are retained for packaging. Sheridan (1983) and Bessette (1985) described, in detail, the trawl-caught fauna from the Galveston Bay system. Incidental species to be kept alive and sold for human consumption, such as crabs, *Callinectes* sp., and flounder, *Paralichthys* sp., are transferred to another compartment. Live shrimp are placed in the remaining compartments.

When the boat reaches shore, the live shrimp are transferred to stationary holding tanks. Shrimp are sometimes transported in aerated tanks on trucks to dealers not located near the landing site.

Holding Tanks at Retail Outlets

Shrimp holding tanks or boxes are generally of two functional types. One type is lowered into the water where circulation is accomplished by natural currents. The other type is placed some distance from the water's edge and requires a pump for circulation.

Holding tanks that are suspended in the water are usually constructed in one of three ways: Wooden frames with wooden slats, wooden frames with perforated fiberboard on the sides and bottom, or metal frames enclosed in heavy galvanized mesh wire. By far the most common and least expensive is the slatted holding tank. The wooden slats are of cypress as it is quite durable and does not swell excessively. The slats are placed from $\frac{3}{16}$ to $\frac{1}{4}$ inch (5-6 mm) apart to retain shrimp and to provide water circulation. The most common tanks in use measure 4 × 4 × 8 feet (1.2 × 1.2 × 2.4 m). All bait boxes that are placed in the water can be raised or lowered as the tide changes and can be lifted free of the water when not in use or during adverse weather or repair. Ropes are attached at each end of the box and pass around a rounded overhead beam turned by handles at either end.

Holding facilities on shore are fabricated primarily from lumber, concrete, and fiberglass. Wooden boxes are most common, but there has been a definite trend toward concrete and fiberglass structures in the last few years. Water is continually circulated through shore tanks by electric pumps, and waste products pass out an overflow (Inglis and Chin, 1966). About one-third of the shore tanks in the Galveston Bay area are equipped with filters to clear the water of debris, silt, and waste products. Most dealers use filters only to clear incoming water, but some also use filters to clean recirculated water. A majority of the wooden tanks measure 4 × 4 × 8 feet (1.2 × 1.2 × 2.4 m), whereas concrete tanks are usually 4 × 4 × 16 feet (1.2 × 1.2 × 2.8 m). Some circular concrete structures are 4 feet (1.2 m) deep and 12 to 18 feet (3.6 to 5.5 m) in diameter (Inglis and Chin, 1966). Circular fiberglass tanks, measuring 2.5 feet (0.8 m) deep and 6 feet (1.8 m) in diameter, are used by some bait-camp operators in the Galveston Bay area.

Keeping Shrimp Alive

Various devices and methods are used to keep shrimp alive. During summer months, water in unprotected tanks often becomes excessively hot; consequently, most tanks are shaded. Shading also retards growth of algae. Ice, held in plastic bags to prevent dilution, is used by some dealers to cool water in holding boxes. Other methods for cooling and aerating include wooden cooling towers, overhead perforated pipes or hoses that spray fresh water into the tanks, and overhead racks covered with burlap bags that cool water by evaporation as it trickles down through the burlap. Some fishermen cool water in holding tanks on their boats by recirculating it through copper tubing covered by block or crushed ice. One bait establishment has a complete electric temperature-control system, but the expense of installation, operation, and maintenance prohibits widespread use of such equipment. During winter the water is warmed by incandescent or infrared lights strung overhead.

Dead shrimp are removed regularly from tanks to reduce fouling and to discourage cannibalism. A net of nylon or cotton mesh stretched flat over a wire loop on a long handle is commonly used to cull waste matter and unwanted animals. The net, pushed slowly along the bottom of the tank, scoops up dead shrimp and recently shed exoskeletons while allowing live shrimp to swim free.

Some dealers attach burlap or a similar coarse material to the sides of their holding boxes so that shrimp will have more resting space, thereby preventing crowding at the bottom and probably reducing cannibalism. The practice of putting small stingrays, *Dasyatis* sp., with barbs removed into holding tanks to keep shrimp moving and thus avoiding suffocation has been discontinued. It is now believed that this practice agitates shrimp to a point where oxygen demand is unnecessarily increased.

Retailing Bait Shrimp

Trade practices of Galveston Bay bait shrimp fishermen and dealers are discussed by Inglis and Chin (1966). All dealers now are selling live shrimp by the quart, but in the late 1950's most dealers sold live shrimp at $0.02 each. Retailing by the quart was adopted because this method eliminates the time-consuming chore of counting shrimp individually and furnishes a more uniform measure of shrimp to the customer regardless of shrimp size. With the exception of 1 year of price wars between dealers (1962), the retail price of domestic live shrimp remained at $2.00 per quart between 1959 and 1966. In the spring of 1967, dealers in all but two areas of the bay system raised the price of live shrimp to $2.50 per quart. By early 1968, a majority of dealers in the Galveston-Texas City area had increased the price of live shrimp to $3.00 per quart. By 1973, the average price per quart had reached $3.50. Increases occurred almost annually between 1973 and 1984 (Table 5). The average price per quart from 1984 to 1987 was $8.50. The retail price of dead bait, which sold for $0.50 per pound through 1968, rose to $1.00 per pound by 1973, and by 1981

Table 5.—Average value of bait shrimp, 1959-87.

Year	Price	
	Live shrimp (quart)	Dead shrimp (pound)
1959-1966	$2.00	$0.50
1967	$2.50	$0.50
1968-1972	$3.00	$0.50
1973	$3.50	$1.00
1974	$4.00	$1.00
1975	$4.50	$1.00
1976-1978	$5.00	$1.75
1979	$6.00	$2.00
1980	$7.00	$2.00
1981-1983	$8.00	$2.50
1984-1987	$8.50	$2.50

reached the present price of $2.50 per pound.

Collecting Statistics

Bait dealerships in the Galveston Bay system are grouped according to the following geographic retailing areas: I, Galveston Island; II, Virginia Point to Eagle Point; III, Eagle Point to Morgan Point; IV, Morgan Point to Smith Point; and V, Smith Point to Port Bolivar (Fig. 5). Fishing areas are designated as: 18.1, West Bay; 18.2, Trinity Bay; 18.3, Upper Galveston Bay; 18.4, East Bay; and 18.5, Lower Galveston Bay. At least 50 percent of the bait dealers and bait shrimp fishermen operating in these areas are interviewed weekly. Daily catch figures, total daily dragging time, area(s) fished, and number of trips are recorded. In addition, 1-quart bait samples are purchased randomly from dealers within each area fished. These samples are iced and returned to the laboratory where the contents are counted, weighed, and identified to species so that weekly estimates can be made of bay-wide species composition.

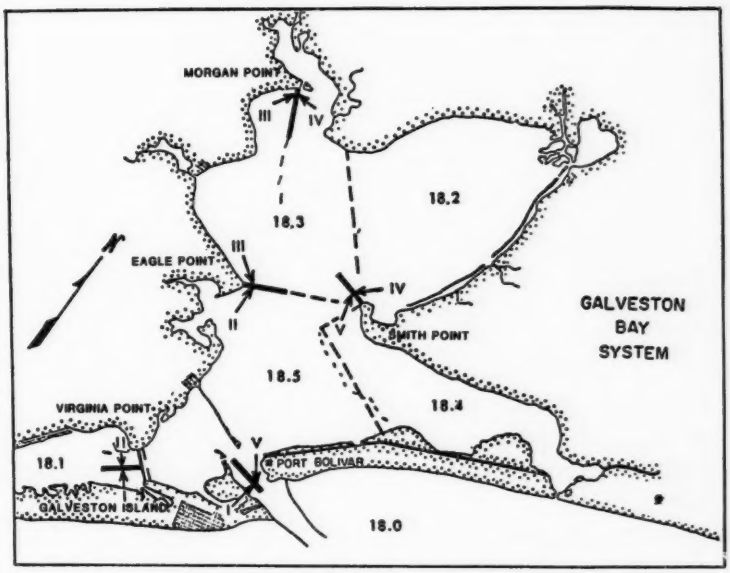

Figure 5.—Retailing areas I-V and fishing areas 18.1-18.5 used during the bait shrimp survey of Galveston Bay.

The interview route is designed to eliminate visiting the same area twice weekly. The usual practice is to canvas dealers in the two areas farthest from the laboratory during the first part of the week. On Monday, for example, area V is covered. On Tuesday and Wednesday, areas II and I are sampled. The two remaining areas are surveyed on Thursday with return calls made on Friday. Although no attempt is made to interview all dealers, a weekly visual check is made of each camp to determine whether it is open for business. A weekly record of the total number of active dealers is kept. With this information and interviews from half the fishery, estimates of total production and total effort are computed.

Interviewing

Until 1985 one person devoted full time to interviewing bait camp operators and bait fishermen during the 7 or 8 months that the fishery is at peak activity. Beginning in 1985, however, interviewing was reduced to include only the brown shrimp season (April-June), to continue the formulation of a bait shrimp index for forecasting. Although the bait fishery is quite active between May and November in most years, during years of mild winter weather, activities continue through December. Dealers are readily available for interviews as their camps are open from early morning until dark. Some who have lighted fishing piers remain open 24 hours a day.

Fishermen are more difficult to interview, chiefly due to their practice of shrimping during early morning and late afternoon hours. This problem has been partially overcome by providing log books to fishermen who agree to keep records of their fishing activities. The logs are left aboard the bait boats and information relative to catch, effort, percentage of catch kept alive, and area fished is copied from them at the convenience of the fishermen. Catch data from those who do not keep logs is more difficult to secure. Often several return trips are required to obtain catch statistics from these fishermen. The key to acquisition of valid data is the positive attitude of the interviewer.

Although all shrimp catch and effort statistics are ultimately converted to pounds and hours, they are reported to the interviewer in a variety of forms such as quarts, pounds, bushels, baskets, tubs, boxes, pails, and numbers. Most catches are given in quarts and pounds, but the interviewer must be familiar with the terminology of each dealer. For example, a bushel of shrimp usually contains 50 pounds, but a box may mean 5 pounds, 1 pound, 12 ounces, or 8 ounces, depending on the dealer. Usually live shrimp are reported in quarts and dead shrimp are reported in pounds, but a few dealers report the entire catch in gallons, bushels, or pounds regardless of whether they are referring to live or dead bait shrimp.

Calculation Procedure

The calculation procedure for estimating total landings and total effort expenditures for bait fishermen operating

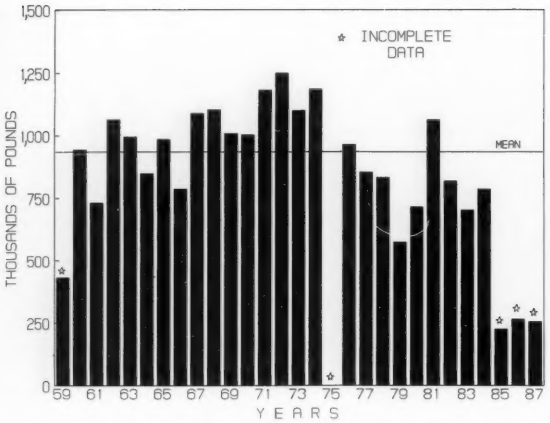

Figure 6.—Estimated annual bait shrimp catch from Galveston Bay, 1959-87.

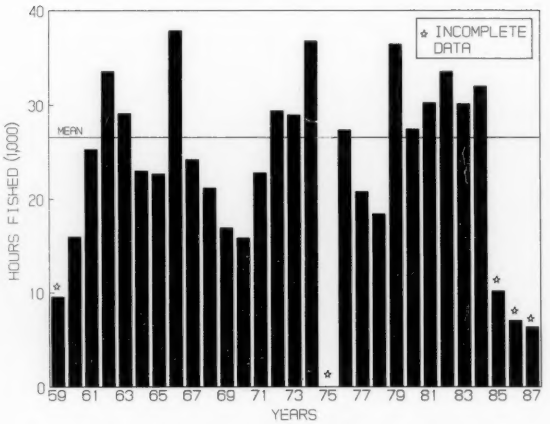

Figure 7.—Estimated annual bait shrimp effort from Galveston Bay, 1959-87.

in the Galveston Bay system is outlined below.

1) Number of active dealers and shrimping vessels are recorded for each area and week.

2) Number of active dealers interviewed and shrimping vessels interviewed are recorded for each area and week.

3) Weekly raw data from each of the five geographic areas of the bay are converted to pounds and hours, with 1 quart = 1.5 pounds.

4) Pounds and hours are summed within each area.

5) And, CPUE calculations are made:

a) Sums of squares for pounds and hours within each area,
b) Mean pounds of bait shrimp produced and mean hours of shrimping effort expended for each area during each week,
c) Variance for pounds and hours for each area,
d) Variance for mean pounds and mean hours for each area,
e) Stratified mean for pounds and hours,
f) Variance and standard errors of stratified means,
g) Estimates of total pounds of bait shrimp handled and total hours of shrimping expended,
h) Confidence intervals at the 80 percent level for catch effort,
i) Stratified estimates of proportions of brown, white, and other entering weekly landings, and
j) An approximation of total pounds of various shrimp entering weekly landings.

Discussion

Galveston Bay bait shrimp fishermen exert only as much effort as it necessary to supply the demand for bait shrimp. Although the 1960-84 catch fluctuated between 0.6 and 1.2 million pounds (Fig. 6), effort varied from near 16,000 to 37,880 hours (Fig. 7). Fishing effort for 1975 was not recorded. Additionally, in recent years there was reduced sampling (1985-87). The average bait catch for 1960-84 was 940,378 pounds. Since 1977 (with the exception of 1981), the annual bait catches have been below average, but average number of hours expended (with the exception of 1977 and 1978), has been above the 1960-84 average of 26,693 hours.

The highest estimated annual catch during the survey was 1,249,100 pounds in 1972. CPUE ranged between 15.7 pounds/hour and 63.0 pounds/hour (Fig. 8), with the poorest years being 1966 and 1979. Unprecedented quantities of fresh water from spring floods decreased salinities in the upper bay during those years, creating conditions not conducive to brown shrimp growth (Gunter et al., 1964; Zein-Eldin and Renaud, 1986). These suboptimal conditions in the bay most likely caused young shrimp to leave the nursery area prematurely. Only a portion of the juvenile brown shrimp stock then remained to be fished by the bait fishery in 1966 and 1979.

Considering that both bait and commercial bay fishermen exploit the same shrimp crop, the below-average bait catches in recent years would suggest that the commercial bay catches should also be below average. This has not been the case. According to Klima et al. (1984), the average commercial catch (heads off) for 1960-82 from Texas bays was 1.9 million pounds. Additionally, for 1984 and 1985 the catches were 7.1 and 5.4 million pounds, respectively (Klima et al., 1987). More specifically, the NMFS Economics and Statistics Office data on Galveston Bay commercial shrimp landings (Fig. 9) indicate above-average landings in recent years. These inconsistencies between bait and commercial bay production might be attrib-

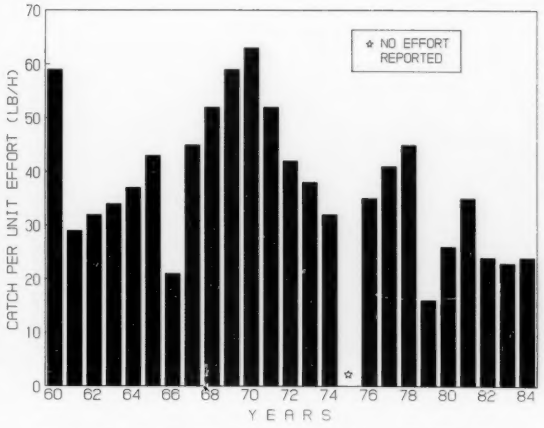

Figure 8.—Estimated catch per unit effort (CPUE) of bait shrimp from the Galveston Bay system, 1960-84.

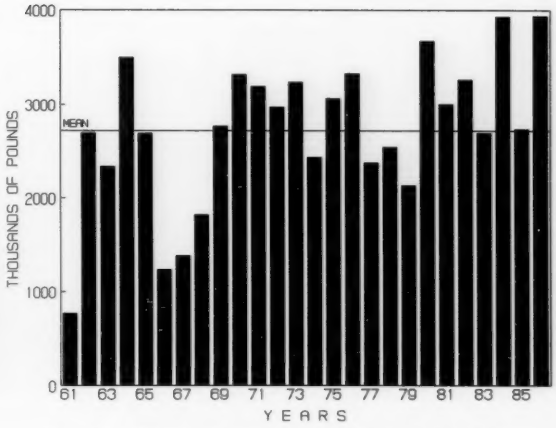

Figure 9.—Galveston Bay commercial landings (heads off) 1961-86.

uted to an increase in the number of boats fishing for commercial purposes.

Extensive changes have taken place in the bait fishery over the past 26 years. Bait shrimp dealerships have evolved from small stands that retailed live and dead bait, rented skiffs and motors, and provided launch ramps, to diversified establishments. In addition to bait shrimp, merchandise now sold includes fishing tackle, boat accessories and supplies, fuel, ice chests, ice, lanterns, food, soft drinks, liquor, and beer. Some have complete restaurants, marinas, and elaborate boat lift and storage facilities.

In summary, information about landing and species composition associated with the bait shrimp industry of the Galveston Bay system has been collected on a weekly schedule from 1959 through 1984 and on a more limited basis since 1985. Collectively, the bait index and the postlarval index (Baxter, 1963; Baxter and Sullivan, 1986) provide: 1) A reliable indication of the subsequent offshore harvest and 2) a long term correlation between juvenile abundance and changing environmental conditions. In addition, insight into local fishing practices and trends provide background for continuing research needed to enhance production and value of the shrimp stock.

Acknowledgments

We are indebted to the bait shrimp fishermen and dealers of the Galveston Bay area, especially Huskey's Bait Camp, for their cooperation during this study and to Dennis A. Emiliani, James M. Lyon, and Frank Marullo who assisted in the collection and tabulation of data. Also, we thank Joseph H. Kutkuhn who provided the statistical design, Frank Patella who computerized the data, and Edward Klima and Peter Sheridan who reviewed the manuscript.

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The Southeast Area Monitoring and Assessment Program (SEAMAP): A State-Federal-University Program for Collection, Management, and Dissemination of Fishery-Independent Data and Information in the Southeastern United States

PETER J. ELDRIDGE

ABSTRACT—*The Southeast Area Monitoring and Assessment Program (SEAMAP) is a state-federal-university program for collection, management, and dissemination of fishery-independent data and information in the southeastern United States. Major activities in the Gulf of Mexico and South Atlantic include shrimp and groundfish surveys, ichthyoplankton surveys, collection of environmental and benthic data, mapping of live and hard bottom areas, investigations of low-oxygen and other environmental perturbations, and the establishment of a regional, user friendly, data management system that can be accessed by all marine management agencies in the southeastern United States.*

Each SEAMAP component is directed by a Scientific Technical Committee under the guidance of their respective Fishery Management Boards in the Gulf of Mexico and Atlantic States Marine Fisheries Commissions. The Committees establish Work Groups to plan and execute SEAMAP activities and submit annual budgets for program events. Committees are assisted by regional coordinators, a data manager, an ichthyoplankton curator, and numerous scientists recruited from participating agencies and universities. The program has been funded at $1,000,000 annually.

Recent programmatic events include shrimp surveys from Perdido Bay, Ala., to Brownsville, Tex.; winter surveys to locate trawlable concentrations of coastal herrings (Clupeidae) in the northeastern Gulf; plankton surveys primarily directed toward bluefin tuna, Thunnus thynnus, *eggs and larvae; larval red drum,* Sciaenops ocellatus, *surveys; nearshore trawling surveys in the South Atlantic; live and hard bottom mapping project in the South Atlantic; and the design and initial implementation of the regional SEAMAP information system.*

Introduction

The implementation of the Magnuson Fishery Conservation and Management Act of 1976 (MFCMA) substantially changed management practices for marine fisheries in the United States. The Act provided for the creation of eight Regional Fishery Management Councils with the specific responsibility of developing fishery management plans (FMP's) for marine resources within a 197-mile Fishery Conservation Zone (FCZ)—now known as the Exclusive Economic Zone (EEZ)—adjacent to the 3-mile U.S. territorial sea. The plans identify, for each fishery, the optimum yield which can be harvested annually, the allowed U.S. harvest, the total allowable level of foreign fishing, and the rules and regulations governing foreign and domestic harvesting. National Standard No. Two of the Act requires that conservation and management measures recommended by the regional councils shall be based upon the best scientific information available.

Three of the councils are located in the southeastern United States: Gulf of Mexico, Caribbean, and South Atlantic. Their combined jurisdiction includes the offshore EEZ waters from Texas to North Carolina, and U.S. waters in the Caribbean. A total of thirteen FMP's have been implemented by the councils and about five more are under development. In addition, about ten State-Federal FMP's either have been implemented or are under development in the southeast. The State-Federal plans are designed to manage species that migrate across state jurisdictions, but remain for the most part within the territorial sea, whereas plans developed by the councils are designed primarily for species that spend most of their life span in the EEZ, although it is acknowledged that many species are located both inside and outside the territorial sea, particularly as juveniles.

All major marine fishery management agencies are represented on the Fishery Management Councils and actively participate in managing EEZ marine resources. In the southeastern United States, these are the state fishery management agencies of Texas, Louisiana, Mississippi, Alabama, Florida, Georgia, South Carolina, and North Carolina, and those of the territories of Puerto Rico and the U.S. Virgin Islands; the Gulf (GSMFC) and Atlantic States Marine Fisheries Commissions (ASMFC); the U.S. Fish and Wildlife Service; the U.S. Coast Guard; and the National Marine Fisheries Service (NMFS). Plans for interstate fisheries within the territorial sea are developed under the auspices of the GSMFC and ASMFC.

A common deficiency encountered during the development of fishery management plans was inadequate or incomplete fishery-dependent (information based on statistics reported by commercial or recreational fishermen) and fishery-independent (information collected

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without direct reliance on such statistics) information. The State-Federal Regional Fishery Statistics Program in the southeast subsequently was formed by NMFS, the fishery commissions, and the states to address the collection, processing, and dissemination of fishery-dependent data; that program has been underway for 7 years and has markedly improved the collection of such data. A similar effort, SEAMAP, for the past 6 years, has collected, stored, and disseminated fishery-independent data.

SEAMAP Program Development

Shortly after the implementation of the Magnuson Act, it became evident to state and Federal fishery management agencies in the southeast that they would be closely involved in developing and monitoring: 1) Numerous management plans, 2) management measures designed to protect and conserve critical fishery habitat, 3) conservation and management programs for marine mammals and endangered species, and 4) programs to use underutilized fishery stocks more effectively. Agencies dealing with these activities depend on cooperative research and management programs, not only among themselves but also with their counterparts in academia and other governmental agencies directly or indirectly involved with managing living resources in the southeast region.

In June and July 1980, the NMFS Southeast Regional Office (SERO) sponsored a series of state-by-state meetings with state, Sea Grant, and Coastal Zone officials to determine needs for cooperative State-Federal planning. Initially, 174 projects were identified throughout the southeastern region. These projects were reduced to 45 that were concerned either with assessment activities or which would require assessment data. Because state and Federal management agencies recognized and supported the need to coordinate assessment and related activities in the southeast, the NMFS Southeast Fisheries Center (SEFC) implemented a Southeast Area Monitoring and Assessment Program (SEAMAP) with an initial task of construction of a Strategic Plan. The Strategic Plan was completed in 1981. Subsequently, two SEAMAP Operations Plans—one for the Gulf of Mexico and one for the South Atlantic—were completed and implemented. The Gulf of Mexico SEAMAP effort was implemented in 1981 and the South Atlantic program in 1983.

Gulf of Mexico and South Atlantic Resources and Fisheries

Fish and shellfish stocks of the United States are an enormous renewable resource; the total reported U.S. commercial catch of fishery resources in 1986 was 6.0 billion pounds, with an ex-vessel (dockside) value of $2.8 billion. Living marine resources in the southeastern United States support the largest individual U.S. commercial fisheries in volume (menhaden, *Brevoortia* spp.) and value (penaeid shrimp, *Penaeus* spp.).

In 1986, menhaden yielded 40 percent of the total poundage (2.4 billion pounds) and southeastern shrimp were worth $623 million.

In 1985, over one-half of all marine angler trips along the Gulf and Atlantic coasts occurred in the South Atlantic and Gulf of Mexico (Anonymous, 1986). Although reliable statistics on sport-fishing value comparable to commercial statistics are not available, it is likely that the value of the recreational fishing sector, including supporting facilities and services, may equal or surpass that of the commercial sector.

The sustained growth in southeastern marine fisheries has generated employment for over 40,000 people in the region. The total economic impact of fisheries on the regional economy is difficult to estimate, but is assumed to be between three and six times the ex-vessel value of the landings, or $2.8-5.6 billion. Table 1 details southeastern commercial landings, by states, for 1985 and 1986.

In addition to the economic contributions of the commercial fishing industry the demand for thrills, pleasure, and tests of skill has made marine recreational fishing another major source of economic revenue. Recently, statistics have been collected on catch and participation in recreational fisheries, and 1985 estimates (Anonymous, 1986) place the number of sport fishermen in the southeast at 6.4 million. These fishermen caught over 222 million fish and spent roughly $3 billion.

SEAMAP Overview

The basic philosophy and approach employed to implement the SEAMAP program is described in the SEAMAP Strategic Plan (Anonymous, 1981). A brief summary is provided here to orient the reader to the description of program accomplishments.

SEAMAP is designed to encompass all fishery-independent data collection activities in the southeast including those pursued by states, territories, and other Federal agencies in the southeastern region. The goal of the program is to maximize the efficiency of data collection and processing in order to provide the best data base possible for management decisions. Also, the program is designed to share and minimize costs among management agencies as well as to pool scientific expertise wherever appropriate. The program utilizes a variety of research platforms including vessels, aircraft, satellites, and observers on commercial fishing vessels. Common activities include trawling, hydrographic and plankton tows, sightings of species of special interests (i.e., turtles and marine mammals), development of regional data bases, and planning for annual field surveys.

SEAMAP projects survey marine and estuarine waters and their living resources within the territorial sea and EEZ contiguous to the southeastern states and territories, from Texas to North Carolina. Where necessary and appropriate, the scope may be expanded

Table 1.—Reported United States commercial landings for southeastern states, 1985-1986[1].

State	Landings, 1985		Landings, 1986	
	Thousand pounds	Thousand dollars	Thousand pounds	Thousand dollars
N.C.	214,871	64,589	168,885	63,435
S.C.	12,827	13,941	16,788	25,064
Ga.	17,241	20,887	15,476	24,501
Fla.	182,577	171,073	166,577	154,501
Ala.	29,559	40,664	36,690	63,988
Miss.	470,648	40,136	418,409	45,581
La.	1,704,498	229,134	1,699,321	321,514
Tex.	102,691	177,147	116,493	246,122

[1]Landings are reported in round (live) weight for all items except univalve and bivalve mollusks, such as clams, oysters, and scallops, which are reported in weights of meats (excluding the shell) (Source: USDOC, 1987).

to include geographical areas outside these boundaries such as open ocean areas in the Gulf of Mexico for pelagic egg and larval surveys, and off the coast of Mexico for coastal stock surveys. Fisheries emphasized include those subject to joint State-Federal or council management, as opposed to those which fall exclusively under the jurisdiction of an individual state or other political entity. Also included are fishery-independent survey activities related to endangered species, especially sea turtles and marine mammals, as well as surveys designed to characterize habitats of critical interest to fishery managers, such as reef areas.

Because southeastern fishery management agencies are responsible for assessments of their marine resources, most SEAMAP activities and projects are directed toward assessment efforts. In particular, fishery management agencies are concerned about: 1) Causes of fluctuations of abundance and recruitment of commercially and recreationally important species, 2) improving understanding of the relationships between fisheries and habitat productivity, and 3) documenting impacts of man's activities on habitats and fishery resources.

Table 2 shows relationships between SEAMAP goals and sources of data. It illustrates that assessment activities can be combined into compatible sampling groups. For instance, bottom trawling, plankton sampling and hydrographic data can be taken sequentially on the same station, whereas it is impractical to combine trawling and purse seine operations on the same cruise. Based on prior survey experience in the southeastern United States, SEAMAP chose to concentrate its initial efforts on bottom trawling and benthic sampling. Plankton and environmental data were also selected to be surveyed in conjunction with trawling and benthic activities. Development of a regional SEAMAP data management system was given high priority to make survey information accessible and useful to participants and managers. In addition to surface vessels, submersibles and satellite remote sensing techniques have also been identified as appropriate sampling platforms, particularly for parameters such as temperature, chlorophyll, and turbidity.

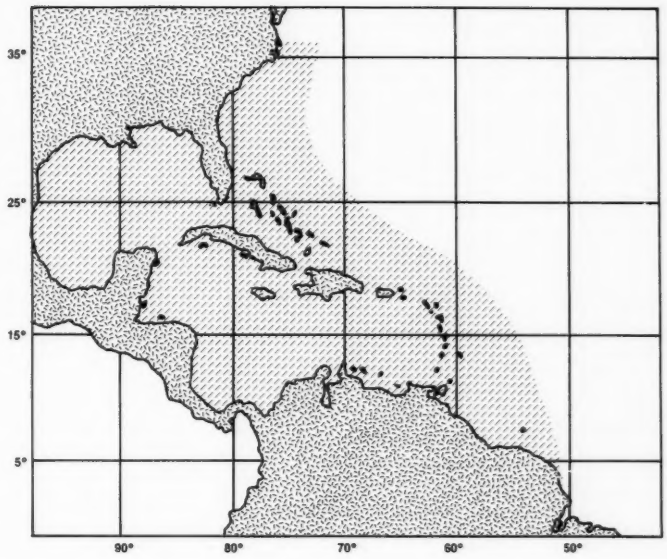

Figure 1.—Overall coverage needed for understanding of the southeastern marine ecosystem.

Table 2.—Primary (P) and secondary (S) sources of data to meet SEAMAP Goals.

		Activity Type												
Goals	Description	Oceanographic sampling	Bottom trawling	Mid-water trawling	Purse seining	Bottom longlines	Surface longlines	Plankton nets	Fish traps	Submersibles	Acoustic surveys	Aerial surveys	Satellite surveys	Data management
I	Reef fish assessment	S	P			P		P	P	P	S			
II	Migratory pelagics assessment	S			S			P						
III	Oceanic pelagic assessment	S					P	P					S	
IV	Groundfish assessment	S	P					P						
V	Coastal herrings assessment	S	S	P	S			P			P	S	S	
VI	Coastal shrimp assessment	S	P					S						
VII	Spiny lobster and stone crab assessment	P						P	S				S	
VIII	Deepwater stock assessment	S	P			P		S	P	S	S			
IX	Precious coral assessment		S							P				
X	Marine mammals assessment	S									S	P	S	
XI	Marine turtles assessment	S	S	S							S	P	S	
XII	Describe resource environment	P	S	S	S	S	S	S	S				P	
XIII	Ecosystem structure studies	P	P	P	P	P	P	P	P	P	P	P	P	
XIV	Resource health monitoring	P	P	P	P	P	P	P	P	S		S	S	
XV	Maintain and disseminate data													P

The geographic area that must eventually be surveyed to gain a complete understanding of the dynamics of the southeastern marine ecosystem is vast (Fig. 1). Much of this region is outside

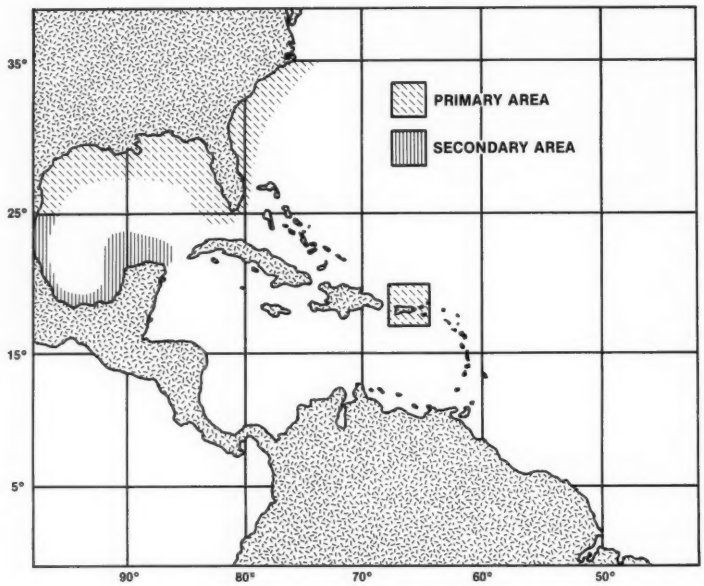

Figure 2.—Basic standardized surveys areas.

the sphere of U.S. jurisdiction and will have to be satisfied through cooperative agreement and coordination with foreign governments and international bodies or commissions. Conversely, most of the short-term specific requirements of the councils, and particularly of the states and commissions, can be met by assessment activities in areas contiguous to the southeastern United States and Caribbean territories. Survey activities in this region (Fig. 2) will provide much of the information necessary for process-oriented and dynamics studies, particularly those dealing with estuarine and coastal interactions.

Initially, SEAMAP concentrated its efforts on the U.S. territorial sea and contiguous zones. Many of these activities arose from research and management needs derived directly from council and State-Federal fishery management plans. For example, the "Texas Closure" in the Gulf Shrimp Plan led directly to a series of SEAMAP groundfish and shrimp cruises designed to evaluate the economic impacts of the closure as well as to help determine starting and ending dates of the closure.

Gulf SEAMAP Program Development

Chronology

Because of an impending need to obtain fishery-independent data upon which to base an evaluation of a major fishery management measure (the Texas Closure), the Gulf of Mexico was selected as the "test" area for SEAMAP. The Gulf of SEAMAP program was implemented in December 1981, under guidelines formulated by the Technical Coordinating Committee (TCC) of the GSMFC. Initial operations were to test the coordination, standardized collection, management, and dissemination of data from three classes of surveys—plankton, bottom trawl (shrimp/groundfish), and environmental.

Results of the initial SEAMAP operations were most encouraging. The shrimp/groundfish survey yielded data on offshore shrimp movements, which were used by Texas and the Gulf of Mexico Fishery Management Council in a cooperative seasonal closure of Texas territorial waters and the EEZ and, subsequently, evaluation of its benefits to the fishery.

The initial ichthyoplankton survey, conducted cooperatively with Mexico, produced the most comprehensive regional collection of fish eggs and larvae ever acquired. Environmental data, collected in association with the ichthyoplankton surveys, produced a Gulf-wide data base that is being used to describe the distribution and abundance of the region's resources. Survey activities were summarized in 1982 and 1983 Environmental and Biological Atlases, 1982 and 1983 SEAMAP Ichthyoplankton Atlases, and numerous reports and other publications.

Other key activities of the program's first year included:

1) Establishment of scientific advisory work groups to assist in planning and coordinating surveys and data reports.

2) Distribution of quick-report (real-time) shrimp and groundfish data—a system designed to return weekly computer plots and data listings to managers, researchers, and fishing industry.

3) Implementation of programs to compile data for an annual SEAMAP Marine Directory, a regional listing of fishery research facilities and survey plans in the Gulf, and SEAMAP Atlases.

4) Development of requirements for a 5-year SEAMAP Operations Plan.

5) Preliminary design of SEAMAP information system.

Second year operations extended the scope of SEAMAP activities further, and included:

1) Expansion of spring-summer survey activities for plankton, shrimp/groundfish, and environmental data, including quick-report information on low bottom oxygen (hypoxia) areas in the Gulf;

2) Generation of the 5-year Operations Plan;

3) Publication of the 1982 Marine Directory;

4) Sponsorship of Shrimp/Groundfish Trawling Gear Assessment workshop;

5) Partial implementation of the SEAMAP Information System.

Potential Yields

Fisheries resources of the Gulf are generally believed to have a strong potential for substantially greater contributions to the region's economy by devel-

Table 3.—Current and estimated potential value of Gulf fisheries by major species/fishery groups (values in millions of dollars ex-vessel)[1].

Fishery	Current value	Potential increase[2]	Total potential value
Shrimp	422.4	20.0	442.4
Menhaden	72.7	96.8	169.5
Coastal pelagics	10.2	1.5	11.7
Reef fish	23.7	2.4	26.1
Coastal herrings	0.6	439.4	440.0
Oceanic pelagics	3.0	0.3	3.3
Groundfish	8.6	110.0	118.6
Oysters and scallops	23.9	6.0	29.9
Crabs and crustaceans	26.7	3.0	29.7
TOTALS	591.8	679.4	1,271.2

[1]All values in 1982 dollars.
[2]Potential increase resulting from added yield to the fishery (expansion) or new products (value added to the fishery from utilization of landings in a more valuable form (e.g., menhaden used as human food at 20¢/pound vs. animal food at 7¢/pound) (McIlwain, 1983).

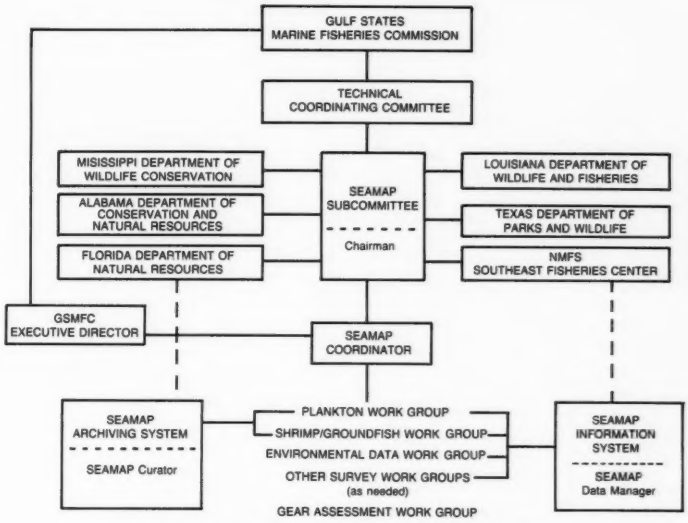

Figure 3.—SEAMAP Gulf program organization.

oping presently underutilized resources and converting currently harvested species to a more valuable form. Thus, the Gulf of Mexico appears to be a prime area for fishery expansion (Table 3), but extensive research will be required to reach this goal. Some of the Gulf's fisheries resources, such as shrimp, *Penaeus* spp., and Gulf menhaden, *Brevoortia patronus*, generate very large commercial returns; others are presently important to both recreational and commercial fisheries (mackerel, *Scomberomorus* spp., and red drum, *Sciaenops ocellatus*). Still others offer a potential for future development (herrings (Clupeidae); Gulf butterfish, *Peprilus burti*; sharks). The resources of greatest general interest to the region, and corresponding priority research objectives, include:

1) Shrimp—Distribution and abundance of all stages, spawning areas, environmental parameters, status of stocks;

2) Coastal pelagics—Distribution and abundance, migration, spawning areas, environmental parameters, status of stocks;

3) Estuarine pelagics—Distribution and abundance, life histories, predator-prey relationships, food habits, migrations, status of stocks;

4) Reef fish, snapper and grouper—Life histories, stock identification, MSY, offshore forage, spawning sites, environmental parameters;

5) Menhaden—Spawning areas, larval transport, age structure, distribution, schooling behavior, status of stocks, environmental parameters;

6) Sharks, tunas, billfish—Abundance, stock recruitment, life histories, environmental parameters; and

7) Squid and butterfish—Abundance and distribution, status of stocks.

Program Organization and Operations

The SEAMAP Subcommittee of the GSMFC's TCC controls the SEAMAP program in the Gulf, subject to policies of participating states, the commission and NMFS (Fig. 3). Membership of the Subcommittee consists of one representative from each of the five Gulf States, Gulf of Mexico Fishery Management Council, and NMFS. Daily functions of the program are managed by the SEAMAP Coordinator under the direction of the Subcommittee Chairman, with administrative supervision from the GSMFC's Executive Director. Planning and execution of SEAMAP activities are provided by scientific work groups appointed by the Subcommittee.

A 5-year operations plan for SEAMAP-Gulf provides organizational guidelines and policies, identifies duties and responsibilities, and presents a proposed series of scheduled surveys and activities for the program (Anonymous, 1984a). The latter includes:

1) Shrimp/groundfish. Brown shrimp, *Penaeus aztecus*; white shrimp, *P. setiferus*; and pink shrimp, *P. duorarum*, in the Gulf of Mexico support the most valuable U.S. fishery. In addition to the landed catch, the shrimp fishery annually discards in excess of 1 billion pounds of groundfish. This discard is composed of over 170 different species, with Atlantic croaker, *Micropogonias undulatus*; spot, *Leiostomus xanthurus*; sand seatrout, *Cynoscion arenarius*; Atlantic cutlassfish, *Trichiurus lepturus*; sea catfish (Ariidae), and silver seatrout, *Cynoscion nothus*, comprising the dominant species.

2) Plankton. Spawning success and the early life history of fishery stocks can be evaluated from collections of fish eggs and larvae. Survey emphasis is placed on species such as bluefin tuna, *Thunnus thynnus*; billfishes (Istiophoridae), mackerels, *Scomberomorus* spp., and other coastal pelagics, coastal herrings (Clupeidae), and drums and croakers (Sciaenidae).

3) Environmental Data. Measurements of critical environmental parameters, such as temperature, salinity and oxygen will be collected to determine how the distribution, abundance, and general health of fishery resources are affected by these parameters.

4) Pelagic Fish. Coastal herrings,

mackerel, jacks (Carangidae), billfishes, and tuna will be sampled by midwater trawl/acoustic surveys, surface longline surveys, and visual surveys of surface-occurring species.

5) Special Programs. Special survey programs will include activities such as mark and recapture experiments, satellite and aircraft surveys, low oxygen and sudden environmental perturbation studies, and sediment mapping.

6) Satellite and Aircraft. SEAMAP visual surveys of surface-occurring fishes, porpoises, and sea turtles may be performed by observers aboard aircraft to provide valuable assessment data on seasonal and geographic distribution of these organisms.

7) Low-Oxygen and Sudden Environmental Perturbation. Often, extreme, rather than normal, environmental conditions result in habitat alteration and species succession. For example, movement of cold, oxygen deficient (hypoxic) waters from the Gulf's floor onto the continental shelf may result in the death of much of the resident benthic community and cause mobile species to leave an area.

8) Sediment. The distribution and abundance of many ecologically important species are associated with sediment particle-size, not only for such deposit feeders as shrimp and some groundfish, but also for their predators. Quantitative relationships, however, have not been determined and must be established if management is to assess the impact on fishery resources of activities such as dredge spoil disposal, bulkheading, and toxic substances.

Program Entities and Duties

SEAMAP Coordinator

The Coordinator's primary responsibility is to assist the Subcommittee in ensuring that the operational system functions efficiently and satisfies user requirements. The Operations Plan and associated Event Logic Diagram, schedule of events, survey plans, and GSMFC and TCC directives constitute the basic documents by which the Coordinator monitors program status, coordinates Subcommittee meetings and operations, anticipates potential problems, and initiates corrective action. Because SEAMAP involves several agencies, the Coordinator must be diplomatic as well as aggressive.

Data Manager

The SEAMAP Data Manager has the overall responsibility for ensuring that verified digital data collected during SEAMAP survey activities are processed, archived, and made available to participants, cooperators, investigators, and others in a manner consistent with approved SEAMAP and applicable NOAA data management policies and procedures. Funding and administration for this position are provided by the SEFC.

SEAMAP Curator

The SEAMAP Curator has responsibility for maintaining collections of ichthyoplankton and other selected organisms collected during SEAMAP survey operations. This position, as well as associated curatorial expenses and support, is funded by SEAMAP and housed at the Florida Department of Natural Resources, Bureau of Marine Research, St. Petersburg, Fla.

Program Facilities

The SEAMAP Program is administered by the GSMFC which provides office space for the SEAMAP Coordinator at the Gulf Coast Research Laboratory (GCRL), Ocean Springs, Miss. Clerical, accounting, and printing services are provided by the commission. Subcommittee and work group meetings are held at the site of GSMFC semi-annual meetings or at other sites selected for their central location.

Information Dissemination

Products resulting from SEAMAP activities may be grouped into two basic categories: Data sets and program information. Data sets include both digital data and specimen collections. Program information is defined here as those communications (reports, bulletins, quick reports, and announcements) that are released to participants, cooperators and investigators, including Sea Grant programs; to the fishing/seafood community; to Federal and regional management agencies; and to the general public via newspapers and other media.

Program Evaluation

SEAMAP program evaluations are conducted periodically through an internal procedure and submitted to the GSMFC's TCC. External reviews can be conducted at the discretion of the TCC. Also, annual regional SEAMAP reports are provided in October at the respective ASMFC and GSFMC meetings.

Budget Planning

The success of the SEAMAP Program is dependent on coordination of regional activities planned for phased implementation, as well as adequate funding for sampling platforms, sampling systems, and scientific and support personnel. The cost-effective nature of the program resides in the accumulated expertise and cooperative history of its participating agencies, in addition to the sharing of costs.

Although the SEAMAP budget was projected to increase gradually over time, funding has been maintained at $1 million annually for both the Gulf and South Atlantic components of the program. This has been a substantial achievement given existing fiscal restraints, and has occurred primarily because of the strong Congressional support that state partners have contributed to the program.

South Atlantic SEAMAP Program

Chronology

Since 1982, annual cooperative state-NMFS cruises have occurred in the South Atlantic using the NOAA Ship *Delaware II*. Results of these cruises have been encouraging and a publication describing the deepwater demersal finfish resources off South Carolina utilized SEAMAP-SA data (Low and Ulrich, 1983).

In August 1983, representatives of Florida, Georgia, South Carolina, North Carolina, the South Atlantic Fishery Management Council, and the NMFS met in Charleston, S.C., to determine the feasibility of establishing a SEAMAP-SA Program. That meeting resulted in the formation of the SEAMAP-SA Committee which defined program goals and made recommendations to the South

Atlantic States Regional Marine Fisheries Management Board (Board) concerning program implementation. The Board met in October, selected program goals, and formally established the program under the auspices of the ASMFC. The SEAMAP-SA Committee was given the task of developing an operations plan for the program in 1984.

The Committee met several times during 1984 to develop the SEAMAP South Atlantic Operations Plan 1986-1990. The plan was accepted by the ASMFC at its annual meeting in October 1984. An Executive Summary of the Plan was produced in February 1985 (Anonymous, 1984b).

Program Organization and Operations

The SEAMAP-SA Committee of the ASMFC controls the SEAMAP program in the South Atlantic subject to policy of the commission and NMFS (Fig. 4). Membership of the Committee consists of one representative from each of the four South Atlantic States, the South Atlantic Fishery Management Council, NMFS, and the ASMFC. Daily operations of the program are managed by the SEAMAP-SA Coordinator under the technical direction of the Committee Chairman. Planning and execution of SEAMAP-SA activities are developed by scientific work groups appointed by the Committee.

The system elements of the South Atlantic program are similar to those in the Gulf and will not be described further. Program operations are detailed in the South Atlantic SEAMAP Operations Plan (Anonymous, 1984b). This section will describe only the major points, and refers the reader to the Plan for additional details. Major activities that will be conducted during the life of the plan include:

1) Shallow Trawling. White, brown, and pink shrimp constitute the most valuable commercial fishery in the South Atlantic states and also support a substantial, but unquantified recreational fishery. Most juvenile sciaenids, king mackerel, *Scomberomorus cavalla*; and Spanish mackerel, *S. maculatus*; menhaden, mullet, *Mugil* spp.; bluefish, *Pomatomus saltatrix*; blue crabs, *Callinectes sapidus*; herrings, jacks, and numerous

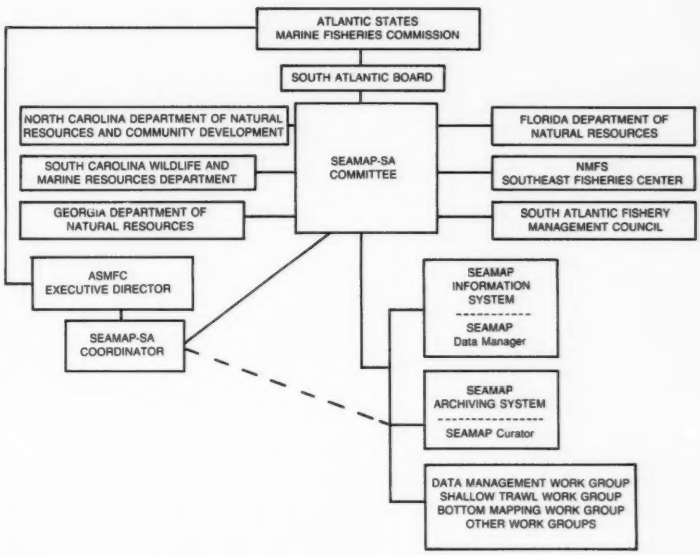
ATLANTIC STATES MARINE FISHERIES COMMISSION
SOUTH ATLANTIC BOARD
NORTH CAROLINA DEPARTMENT OF NATURAL RESOURCES AND COMMUNITY DEVELOPMENT
SOUTH CAROLINA WILDLIFE AND MARINE RESOURCES DEPARTMENT
GEORGIA DEPARTMENT OF NATURAL RESOURCES
SEAMAP-SA COMMITTEE
FLORIDA DEPARTMENT OF NATURAL RESOURCES
NMFS SOUTHEAST FISHERIES CENTER
SOUTH ATLANTIC FISHERY MANAGEMENT COUNCIL
ASMFC EXECUTIVE DIRECTOR
SEAMAP-SA COORDINATOR
SEAMAP INFORMATION SYSTEM
SEAMAP Data Manager
SEAMAP ARCHIVING SYSTEM
SEAMAP Curator
DATA MANAGEMENT WORK GROUP
SHALLOW TRAWL WORK GROUP
BOTTOM MAPPING WORK GROUP
OTHER WORK GROUPS

Figure 4.—SEAMAP-SA program organization.

forage species spend part or most of this life stage in shallow trawling grounds. These species have immense commercial and recreational value and form the basis of the inshore South Atlantic fisheries. While current state projects, primarily for shrimp, are sufficient for some basic management needs, the coordinated, standardized SEAMAP-SA surveys are needed to provide supporting ecological data.

2) Passive Gear. Passive gear includes traps, hook and line, bottom-tending longline, kali poles and fish sticks, and television. High priority species that will be monitored by one or more of these gears are black sea bass, *Centropristis striata*; snappers, groupers, *Geryon* crabs, and tilefish (Malacenthidae). Numerous lower priority species can also be monitored at the same time. Passive gear surveys will cover waters of the continental shelf and slope throughout the area south of Cape Hatteras and typically will be conducted during summer when sampling is most efficient because of moderate weather.

3) Midwater/Highrise Trawling. Although survey techniques have not been fully developed, it is presumed that midwater or highrise trawls will monitor king and Spanish mackerel, bluefish, shad, *Alosa* spp.; river herring (Clupeidae), squid, and several species of herrings and jacks. Acoustic survey techniques may also be employed in conjunction with trawling.

4) Concomitant Activities/Plankton Surveys. Coordinated, area-wide plankton surveys will be undertaken to gain insight into recruitment processes and general productivity.

5) Environmental Data. SEAMAP-SA will obtain the data necessary for assessing synoptic patterns of critical environmental driving forces. Vessel activities provide ground truth information for calibrating satellite imagery, while expanding in time and space synoptic patterns of sea surface conditions.

6) Mapping and Assessment of Hard Bottom Resources. Because the nature of the substrate is a major determinant of faunal composition, a detailed description of surficial geology will be compiled. Features to be included are amount of live bottom, relief, and nature of the surface sediments. Also, SEAMAP-SA will periodically survey live bottom areas to determine whether they are stable, increasing, or diminishing.

7) Vessel Visual Surveys. Many eco-

logically and economically important species spend a portion of their time at or near the surface where they are readily visible. Since menhaden, other coastal herrings, mullet, mackerels, turtles, marine mammals, and other pelagic species can frequently be observed from a vessel, visual surveys will be conducted in a "piggy-back" manner to minimize costs. These data will be added to the SEAMAP data base.

8) Support Surveys for Stock Definition and Migration Patterns. Fishery management must take into account the stock structure and migratory patterns of exploited species. However, such information is lacking for some important fishery species, including king and Spanish mackerel, bluefish, and several sciaenids. SEAMAP will provide a coordinating mechanism and the basic logistic support for regional biochemical, morphometric, and tagging studies.

9) Assessment of Hard Bottom Resources (Biotic and Abiotic). After the initial mapping of the south Atlantic has occurred, periodic assessments will be made to monitor the extent and quantity of live and rough bottom and to fill identified data gaps. Television, photography, divers, and bottom dredging should be useful here, as could observers in submersibles. Proposed mining sites are likely areas for special surveys to evaluate potential impacts of developmental projects on living marine resources and associated habitat.

10) Environmental Perturbation Surveys. Short-term environmental perturbations frequently have important biological and socioeconomic effects. Events such as oil spills, hypoxia, and hurricanes, for example, usually affect both marine resources and the users of those resources. Agencies which must respond to or cope with consequences of environmental perturbations need factual information on which to base their actions. They need both advance information which allows them to anticipate what will happen to marine resources and on-site descriptive information during and immediately following the emergency.

11) Pelagic Longlining Surveys. Pelagic longlines are used to capture large fish such as tunas, *Thunnus* spp.; swordfish, *Xiphias gladius*; marlins (Istiophoridae), and pelagic sharks living between the surface and mid-depths. Although methods of fishing longlines are well established through extensive commercial experience, an area-wide survey design has not yet been developed.

12) Contaminant Surveys. Some surveys, such as the NOAA National Status and Trends Program, will examine index species for contamination of heavy metals, hydrocarbons, or other toxins. SEAMAP provides a mechanism for the collection of specimens, as well as the sediments upon which their prey organisms feed.

13) Sediment Surveys. The distribution and abundance of many ecologically important species have been qualitatively associated with sediment particle size. This is true not only for detritus and opportunistic feeders such as shrimp and some groundfish, but also for their predators. Quantitative relationships, however, have not been determined and will be required if management is to assess the impact on fishery resources of activities such as disposal of dredge spoil and toxic substances and bulkheading.

14) Calibration of Gear and Standardization of Survey Procedures. Existing survey techniques are not totally adequate for assessing populations of some species, notably those inhabiting live/rough bottom and schooling midwater or pelagic species such as squid, herrings, and jacks. Initially, SEAMAP-SA will attempt to develop survey methods that are both scientifically sound and cost-effective.

15) Data Management Procedures. SEAMAP data management procedures in the South Atlantic are similar to those described for the Gulf.

16) Specimen Archiving. Specimen archiving procedures in the South Atlantic are the same as those in the Gulf.

Program Administration, Entities and Duties

SEAMAP-SA is one of several cooperative State-Federal programs under the aegis of the ASMFC's Interstate Fisheries Management Program (ISFMP). The ISFMP includes several of the Atlantic coast's important fisheries, such as southern shrimp, Atlantic menhaden, *Brevoortia tyrannus*; and striped bass, *Morone saxatilis*, as well as the South Atlantic Cooperative Statistics Program. Under the ISFMP, policy and fiscal matters are addressed by an executive group composed of state marine fishery management agency directors and the NMFS Regional Director, while a technical committee is responsible for plan preparation and execution. These roles are filled by the Board and the South Atlantic SEAMAP Committee, respectively for SEAMAP-SA.

In addition to the Board and Committee, ad hoc work groups are established by SEAMAP-SA as needed to address specific issues. Work groups are not standing committees but are formed to accomplish a specified task and are disbanded upon its completion. Members of work groups are drawn from government agencies and institutions, academia, and other sources of appropriate expertise.

South Atlantic SEAMAP Committee

The South Atlantic SEAMAP Committee generally meets on the call of the Chairperson. The Chairperson and Vice Chairperson are elected annually by committee members and may serve an unlimited number of 1-year terms, consecutively or otherwise.

SEAMAP-SA Coordinator, Data Manager, Work Groups, and Information Dissemination

All South Atlantic activities are similar to those in the Gulf of Mexico.

Program Facilities

Office space for the SEAMAP-SA Coordinator is provided by NMFS at the Miami Laboratory, Miami, Fla. Clerical support, telephone facilities, postage, and office supplies are also provided by NMFS.

Program Evaluation

The purpose of program evaluation is to improve SEAMAP's efficiency and its utility to its primary clients, namely, policy makers, fishery managers, industry researchers, and others who need information about living marine resources and their environment. Responsibility for evaluation will reside with the Com-

mittee, which may delegate portions as appropriate to the Coordinator, Work Groups, Data Manager, and Curator. External evaluation can be accommodated at the direction of the Board, Commission, or Committee.

Budget Planning

Funding procedures for the Gulf of Mexico and South Atlantic programs are virtually the same and have been described earlier in this report. Proposed budgets for both SEAMAP components are given in Anonymous (1984a,b).

Present Status of SEAMAP Program

The program presently consists of two operational components, SEAMAP-Gulf of Mexico, which began in 1981, and SEAMAP-South Atlantic, which began in 1983. A third component, SEAMAP-Caribbean, is in the pre-planning phase. Federal programmatic funding for SEAMAP activities and administration was appropriated in fiscal years 1986-1988 (1 October 1985 through 30 September 1988). State and commission funding allocations are through State-Federal cooperative agreements administered by the SEFC. Past budgets have been about $1,000,000 annually in Federal funds with a lesser contribution by participating states.

Recent Events in Gulf and South Atlantic SEAMAP Program

Shrimp/Groundfish Surveys

In 1985 and 1986, state vessels sampled nearshore waters from Perdido Bay, Ala., to Brownsville, Tex., while a NOAA vessel surveyed offshore waters in the northern Gulf. Catch rates and length-frequencies of penaeid shrimp and finfish, standardized to a 40-foot shrimp trawl, were determined through day and night sampling, on shrimp and groundfish resources. Plankton samples and environmental data were collected at all stations. In addition, a preliminary evaluation of ship vs. laboratory (shoreside) measured weights of selected trawl-caught species was made during the summer to assess the accuracy of shipboard weighing procedures.

Coastal Herring Surveys

Two winter surveys to locate trawlable concentrations of coastal herrings (anchovies, sardines, chub mackerel, *Scomber japonicus*; scad, *Decapturus* sp.; butterfish, etc.) were conducted in the northeastern Gulf in 1985 and 1986 in depths from 46 to 455 m. A high-opening bottom trawl and a Shuman trawl were used. The Shuman trawl appeared to be the most efficient with the largest catch 5,029 pounds of fish in a 30-minute tow; of the areas surveyed, that of southwest Florida was most productive.

Spring Plankton Survey

Two surveys were conducted in the spring of 1985 and 1986, primarily directed toward bluefin tuna eggs and larvae in offshore waters. Samples were collected from the Florida Keys to Brownsville, Tex. Specimens were sent to the Plankton Sorting Center at Szececin, Poland, for identification and will be returned to the SEAMAP Archiving Center in St. Petersburg, Fla.

Summer Squid and Butterfish Survey

The rapid implementation of the Summer Squid/Butterfish Survey illustrates one of the major advantages of the SEAMAP Program; namely, a viable mechanism for coordinating region-wide survey activities. In this case, the newly-formed Squid/Butterfish Work Group met in mid-June and recommended a preliminary sampling plan, which was approved by the Subcommittee. Stations were generated, gear purchased and evaluated (special 24 m trawl nets with ½-ton steel V-doors) and a data management system established to process quick reports of survey data for distribution to management agencies and others interested in potential new Gulf fisheries. A total of 150 stations was made, at depths from 60 to 530 m in July and August 1985. In May and June 1986, another squid and butterfish survey was conducted. The results of this effort indicated that additional effort was needed to design more efficient sampling strategies for assessment purposes. This was to be initiated in 1987.

Larval Red Drum Surveys

Mississippi conducted fall surveys in 1985 and 1986 to collect larval red drum and analyze patterns of distribution, abundance, and species complexes associated with environmental factors. Samples were sent to the Polish Sorting Center to sort the remaining families.

September 1986 Plankton Survey

The increasing concern for the health of king mackerel stocks in the southeast led to approval of a second SEAMAP survey to assess the abundance and distribution of king mackerel eggs and larvae throughout the region; the first such survey was completed in August 1984. Coverage for the 1986 survey was much broader, extending along the southeast U.S. coast and including almost the entire Gulf of Mexico from the Florida Keys west to Brownsville, Tex., and throughout Mexican Gulf waters. Vessels from the Gulf states of Florida, Alabama, and Mississippi, and from NMFS and the Mexican National Fisheries Institute, surveyed from 2 to 27 September 1986 using the standard bongo array and neuston nets.

Associated Plankton and Environmental Data Surveys

For the fifth year, plankton samples and environmental data were collected routinely during SEAMAP surveys. Samples were taken with a 60 cm bongo array and standard NMFS neuston net. Samples from one side of all bongo tows were shipped to the SEFC Miami Laboratory for transshipment to Poland where they will be sorted to the family level at the Polish Sorting Center; the other sample from each station is retained as a back-up in the event of damage or loss of the specimens sent to Poland.

Several environmental parameters were measured at each SEAMAP station: Temperature, salinity, and oxygen levels from surface, middepth and bottom waters; wind direction and speed. Additional water samples were filtered and sorted onboard the vessels for later laboratory analysis of chlorophyll *a*.

Trawl Calibration Exercise in South Atlantic

Vessels from North Carolina, South Carolina, and Georgia conducted a trawl calibration exercise in Charleston Harbor, S.C., in November 1985 to standardize inshore trawling procedures in the South Atlantic. Results of the work were published in Low and Whitaker (1986).

Nearshore Trawling Project in South Atlantic

Vessels from North Carolina, South Carolina, and Georgia conducted a nearshore trawling project in the fall of 1986 to obtain data for development of a sampling design for shrimp and groundfish resources. A second survey was conducted in the summer and fall of 1987 to refine the sampling design. Results of the 1986 work were analyzed and incorporated into the design for the 1987 work by holding a workshop in June 1987. Principal species of interest included shrimp, sciaenids, menhaden, and juvenile mackerels.

Bottom Mapping Project

A bottom mapping project was completed in the south Atlantic in order to develop procedures to establish a long-term computerized data base to describe bottom types and associated fishery resources. Specific objectives of the study included: 1) Defining user needs of resource management agencies concerned with hard bottom resources, 2) identifying types of physical and biological data needed to satisfy user needs, and 3) developing criteria and procedures to evaluate existing and future data bases.

Geryon Crab Project

SEAMAP is providing funds to augment a research effort cooperatively funded by the Gulf and South Atlantic Fisheries Development Foundation, Inc., the South Carolina Wildlife and Marine Resources Department, the South Carolina Sea Grant Consortium, and the Marquette Foundation to determine the distribution and abundance of *Geryon fenneri* and other decapod species of the continental slope. First-year results indicated that maximum catches occurred in the 458-549 m strata, with catches largest on bottom sediments of silt-clay and foraminiferan tests. Additional information is given in Wenner and Ulrich (1987).

Stock Identification Project

The newly-formed Stock Identification Work Group was charged by the Committee to begin planning stock identification studies on species important to the south Atlantic states. The specific objectives are to review and evaluate stock identification techniques for applicability to selected species, such as the mackerels and red drum. A plan noting key species and procedures will be prepared and distributed throughout the region, with an emphasis on coordination with the SEAMAP-Gulf efforts to identify stocks of red drum.

System Design Study for SEAMAP Data Management System

During 1986 both SEAMAP components authorized a Contractor to develop a comprehensive system design and implementation plan for a regional SEAMAP data management system. The study was completed in March 1987 and implementation of the system has been initiated. The system will be a decentralized distributive processing system with state sites entering and editing data. Then, information will be forwarded to a central NMFS site for storage and archiving. Local sites using IBM[1] Personal Computers will have extensive analytical and storage capability for their own files. Regional files will be maintained on the NMFS mainframe computer and will be available to all participants. System implementation will take about 3 years. An overview of the SEAMAP information system is illustrated in Figure 5.

Special Studies

Red Drum Stock Identification and Research Plan

In 1986, specimens of young-of-the-year inshore red drum were collected from discrete estuarine systems by all Gulf States, North and South Carolina, Georgia, and eastern Florida and examined by biochemical means to determine stock structure in the southeastern United States. Also, in response to urgent fishery management needs in the Gulf of Mexico, scientists in that region prepared a State-Federal Cooperative Program for Red Drum Research in the Gulf of Mexico: A Three-Year Plan. Major portions of that plan were implemented in 1986 and 1987.

Status and Trends Benthic Surveillance Study

For the third consecutive year, the SEAMAP Program actively participated in the nationwide sampling for contaminants in coastal fishes and sediments, as part of the NOAA National Status and Trends Program. Both SEAMAP programs supplied personnel from state management agencies to provide guidance in locating concentrations of the target species, Atlantic croaker and spot. Sampling occurred in 14 Gulf and South Atlantic sites from August-October 1986, with a NOAA vessel serving as the primary sampling platform. Analyses of trace metals, organics, chlorinated hydrocarbons and other contaminants as well as histological examinations, are being conducted by the NMFS Beaufort and Charleston Laboratories.

Cooperative King Mackerel Research Program

Because of sharply declining catches of king mackerel in the Gulf of Mexico, scientists utilized the SEAMAP program to coordinate and develop a king mackerel research program. This was accomplished in 1986 and is still serving as guidance for king mackerel research presently being conducted.

The three programs discussed above illustrate one of the major benefits of the SEAMAP program; namely, there is an infrastructure of agencies and scientists available to move quickly toward solution of management and research problems in the southeastern United States. This is true not only for regional problems, but also for national programs, such as the Status and Trends Benthic Surveillance Study, of which the southeastern region is only one component.

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

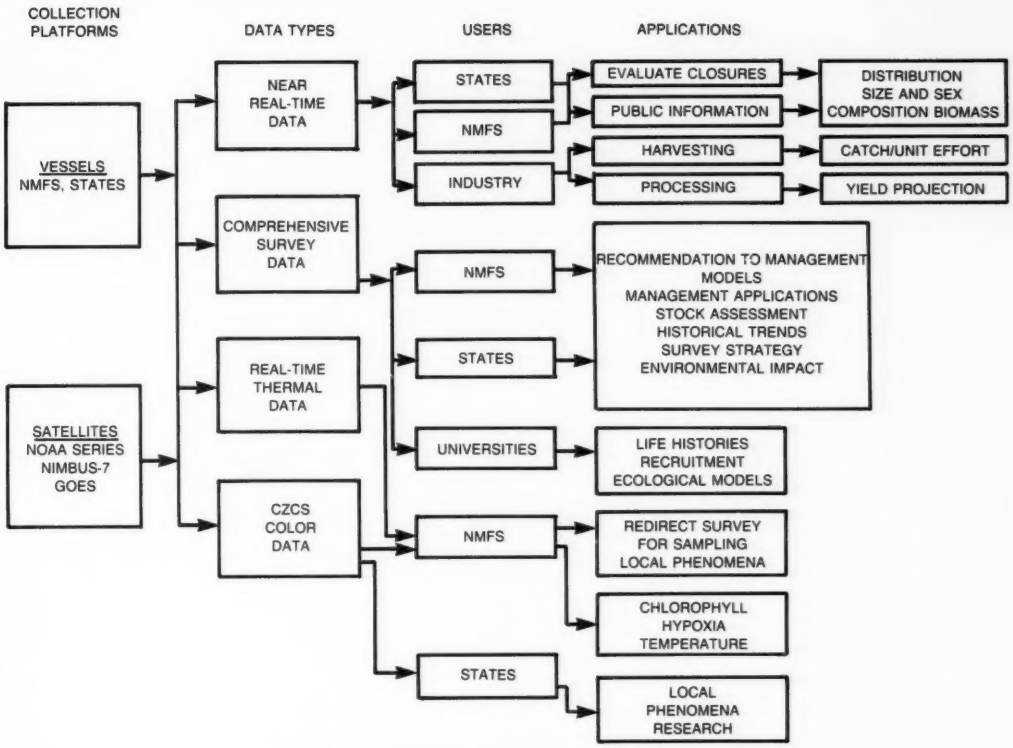

Figure 5.—SEAMAP information system overview.

Summary

The SEAMAP program is the only comprehensive regional program in the United States that involves the collection, analysis, and dissemination of a wide range of fishery-independent information. It has many state, State-Federal, and Federal partners and represents a coherent effort to share financial and scientific resources to collect cooperatively needed fishery-independent data for understanding and maintaining marine fishery resources of the nation at minimal costs. It is a young and dynamic program that is learning as it goes. It has growing pains, but it also has many successes and can serve as a model for other regions that face similar management and research problems.

Acknowledgments

The author is indebted to William Fox, Andrew Kemmerer, Walter Nelson, Perry Thompson, Warren Stuntz, Ken Savastano, and Nikki Bane, who implemented and guided SEAMAP in its initial years. Thanks are due to the Gulf and Atlantic States Marine Fisheries Commissions that sponsor and administer the program. Special thanks are due to the numerous, dedicated state and Federal personnel, who belong to the committees and Work Groups that actually plan and execute SEAMAP activities and surveys. Also, Andrew Kemmerer, Nikki Bane and Scott Nichols provided valuable suggestions for improvement of the manuscript in their reviews.

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The Traditional Central California Setnet Fishery

EDWARD UEBER

ABSTRACT—*In 1984, the central California traditional (non-Vietnamese) setnet fishery was calculated to consist of 266 fishermen fishing from 133 different vessels. These men fished with set gill, trammel, and suspender nets predominantly for Pacific halibut,* Hippoglossus stenolepis*; rockfish,* Sebastes *spp.; white croaker,* Gengonemus lineatus*; shark (Squaliformes); lingcod,* Ophiodon elongatus*; and sablefish,* Anoplopoma fimbria. *The estimated capital value of the traditional setnet vessels and the setnet gear in 1984 was $11,000,000. Fixed and variable costs (excluding crew wages) were estimated at around $3,500,000, and ex-vessel revenues were about $4,000,000. Results in this report pertain only to the traditional setnet fishery and should not be extrapolated to include either the Vietnamese fishermen or the fishery in which Vietnamese setnetters fish.*

Introduction

Setnets, curtainlike fishing gear designed to entangle fish or catch them by the gills, have been under study in recent years. In 1984, the California Department of Fish and Game (CDFG) began a study of the central California setnet fishery to determine its scope and the incidence and magnitude of captured birds and mammals. Concurrent with this study was a continuing project conducted by the national Sea Grant Program and the National Marine Fisheries Service to develop methods less controversial than setnet fishing and, where possible, to introduce new gear which would capture the desired fish but not birds and mammals.

Another reason for the study was a desire by industry and the CDFG for an economic assessment of the fishery. The California legislature wanted to learn the number of active setnet fishermen and the importance of setnet revenues to fishermen's total income. Two other areas of legislative interest were fuel consumption and safety conditions aboard setnet vessels.

The foremost objective of this study was to determine the number of active setnet fishermen and to provide an economic and descriptive profile of the setnet fishery. Secondary objectives were to assess the costs of setnet fishing and the ex-vessel revenues attributable to it, and to gather information about vessel fuel use.

The setnet fleet was known to consist of Vietnamese and non-Vietnamese (traditional) fishermen. Due to language difficulties, the author was unable to obtain information from Vietnamese fishermen. This report, therefore, represents only the traditional sector of the central California setnet industry.

Background

In California, setnets include gill nets and trammel nets. Trammel nets include the traditional three-wall trammel nets ("trammel" nets) and suspender gill nets ("suspender nets"). A gill net is a single-walled net which is hung taut (without slack) (Fig. 1A). Fish are generally caught in such nets by having their gill covers hooked on the netting; this is called gilling.

Trammel nets (Fig. 1B) are three-walled nets with a slack inner wall of small mesh and two outer walls of taut large mesh, one wall on each side of the inner wall. Fish swim through the larger outer mesh, strike the small inner mesh, and push the small mesh through the other outer wall. This loop of small mesh forms a pocket and the fish are trapped (Clark, 1931).

Suspender nets are legally designated as trammel nets in CFG Code 8700 and are identical to gill nets except that lines (suspenders) are attached between floatrope and footrope (Fig. 1C). The suspenders cause the single-wall net to bag or become slack. Suspender nets both gill and entangle fish. Fishermen who use suspender nets claim that they are easier to empty, less expensive, and catch a wider range of species. Trammel net users say that the three-wall net is better for catching Pacific halibut, *Hippoglossus stenolepis*, and that sharks and other fishes do not fall out of the net as easily as from suspender or gill nets.

In 1982, the Pacific Coast Groundfish Plan, developed by the Pacific Fishery Management Council (PFMC) and approved by the Secretary of Commerce as prescribed in the Magnuson Fisheries Conservation and Management Act of 1977, became law. This plan prohibits fishing for groundfish with set trammel or gill nets north of lat. 38½°N (Point Reyes) in the U.S. fishery conservation zone (FCZ). In areas south of lat. 38½°N, Article 5 of the CFG Code, Section 8680 through 8693, is the governing regulation in California ocean waters and the FCZ (PFMC, 1982).

In 1983, 1984, and 1985, Article 5 was changed, and in 1986 new CFG permit regulations were instituted. The new Article 5 does not apply to setnetters fishing in the FCZ[1]. The 1986 permits are nontransferable and obtainable by qualified fishermen only. The new regulations limit the number of permits to 135

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[1]Carper, H. A. 1986. Letter to Joseph C. Greenley, 6 March 1986, Sacramento, Calif.

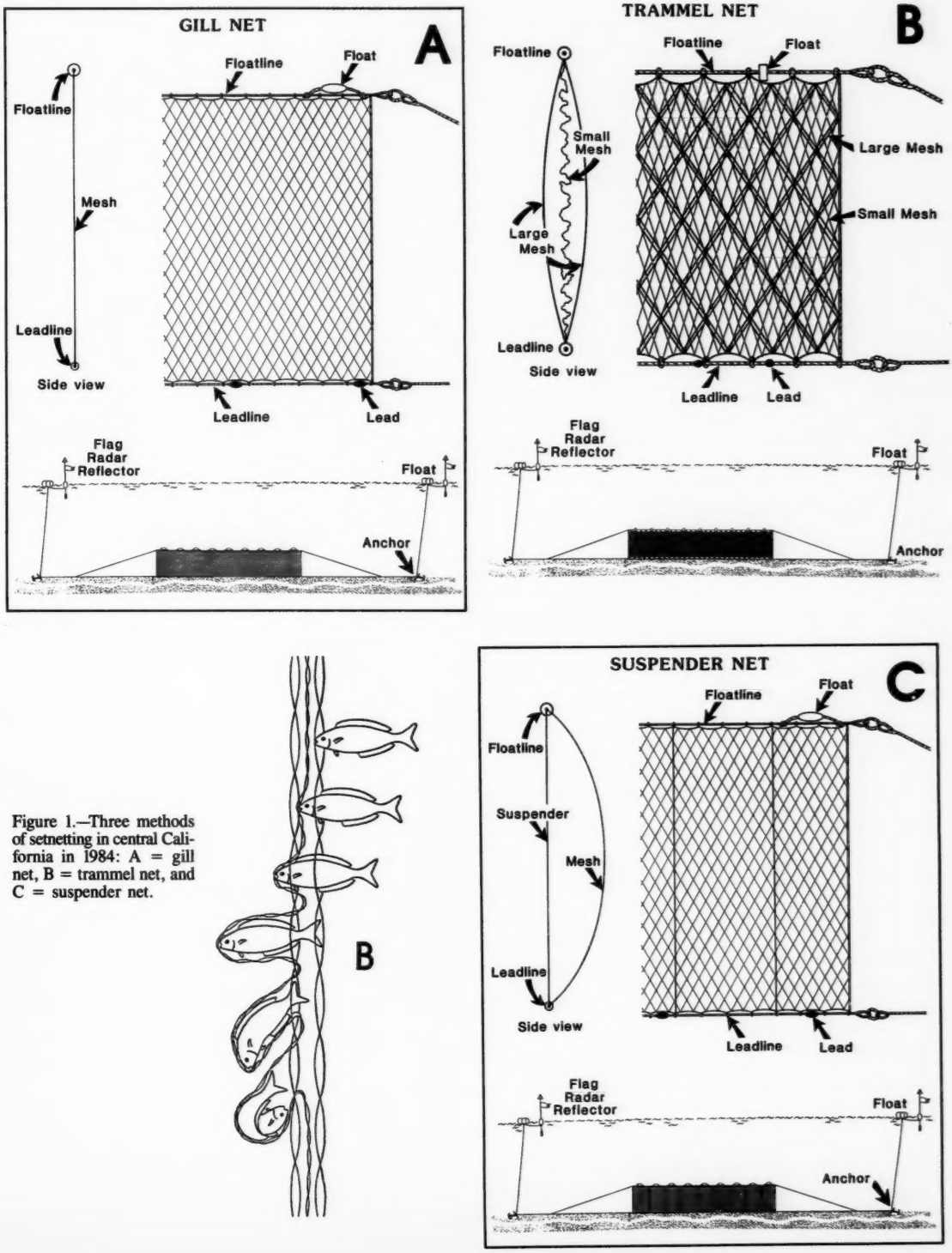
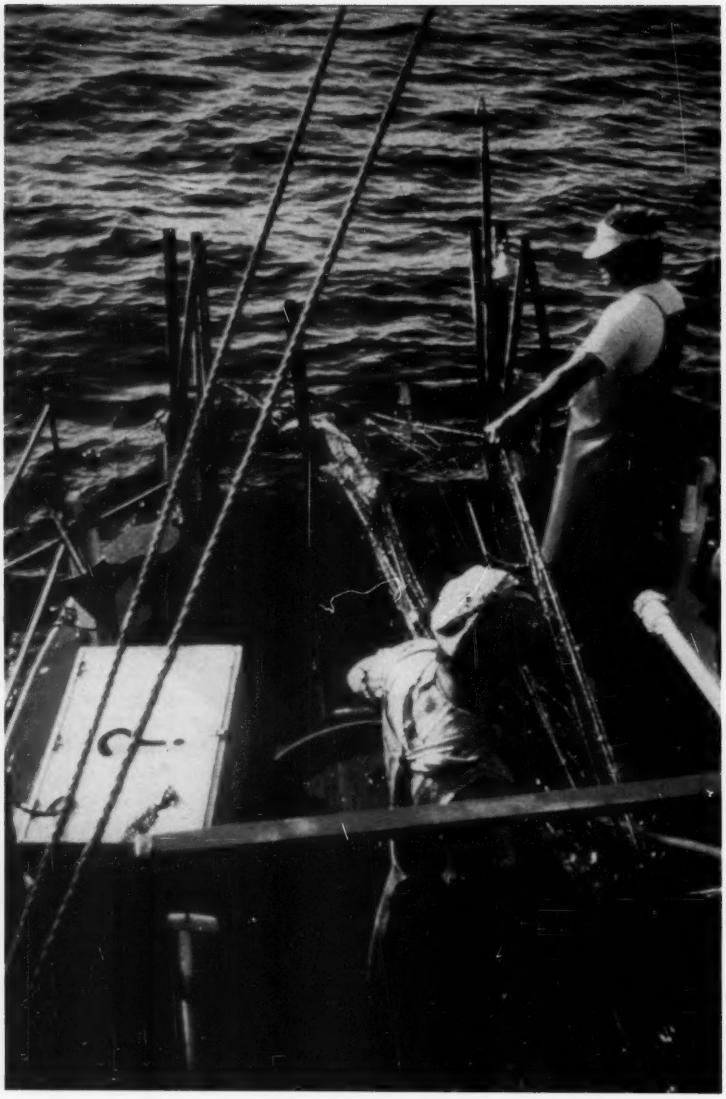


Figure 1.—Three methods of setnetting in central California in 1984: A = gill net, B = trammel net, and C = suspender net.



Retrieving a gillnet in the angel shark fishery. Photo courtesy of Constance Ryan.

in the nearshore trammel-net and suspender net fishery for Pacific halibut, *Hippoglossus stenolepis*, and the gillnet fishery for white croaker, *Genyonemus lineatus*, and nearshore rockfish, *Sebastes* spp. It is hoped that these regulations will diminish setnet interaction with other fishermen, birds, and mammals.

History

Setnets which gill or entangle fish have been used in the Americas for over 7,800 years. Archaeologists believe that the Chinchorro society, one of the oldest in the Americas, depended on setnet fishing for its supply of protein (Allison, 1985). Records of setnet fishing also exist from west coast North American native societies. Native Americans of Washington, Oregon, and Canada constructed setnets from line made of stinging nettle. The use of nettle to make line for fishing nets was also known in early Europe. "In fact the word 'net' is derived from 'nettle' " (Stewart, 1977).

In 1878, Spencer F. Baird, introduced setnets from Europe to Cape Ann, Mass., fishermen (Collins, 1882). These nets proved very effective and their use spread quickly. By 1888, gill and trammel setnets were being used in California and accounted for 76 percent of the value of all fishing apparatus in California excluding the value of the vessels (Collins, 1892).

By 1915, only trammel and gill nets were allowed south of Carmel Point, Calif., as trawl and paranzella nets were banned (Scofield, 1915). Set trammel and gill nets and drift gill nets were used in southern California to catch white seabass, *Atractoscion nobilis*; flatfishes, Pleuronectiformes; rockfishes, *Sebastes* spp.; Pacific barracuda, *Sphyraena argentea*; and crabs. White seabass was the most important species taken by setnets before 1930 (Whitehead, 1930), but Pacific halibut and rockfishes were also targeted.

The striking feature of all the set and drift nets used through the centuries by disparate peoples is their similarity. Setnets employed by native fishermen in 6000 B.C. were designed and fished exactly as the nets used today in central California. The only difference is the material used in net construction. Lines are no longer made of crushed nettle fiber, but synthetic nylon fiber. Floats of wood, reed, cork, or glass have been replaced by plastic. Anchors of stone have become the exception to the more common steel anchors, and footropes are weighted with lead, not rocks, waterlogged sticks, or ceramic clay.

Although materials have changed, setnets remain devices which gill (gill nets) or entangle fish (trammel nets). Set gill nets used in Calfiornia in 1888 had from 2- to 8-inch mesh; the set gill nets in 1986 had from 2⅛-to 9-inch mesh. Trammel nets in 1888 generally had an inner wall of 8-inch mesh; today 8-inch mesh is still the most frequently used.

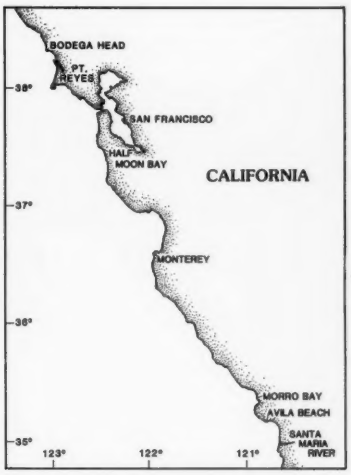


Figure 2.—The study area.

Gillnet on reel, Berkeley, Calif., 1984. Photograph by the author.

There has been a change in California in the public's perception of the deployment, quantity, location, and species which are exploited with set gill and trammel nets. Although fishermen have been using trammel nets to catch halibut and sharks continually since the 1880's, gillnetting of white croaker, rockfishes, and lingcod, *Ophiodon elongatus*, has mostly occurred since 1980. Much of this increase has been by ex-salmon trollers using trammel nets (Anonymous, 1986) and Vietnamese fishermen using gill nets. This expansion has caused public concern because of the incidental catches of marine birds and mammals reported in the media.

Methods

A list of all set gillnet permits was obtained from CDFG offices in Monterey and Menlo Park. These two offices issued over 95 percent of the permits to fishermen who fished from Point Sal (10 miles west of Santa Maria) to Point Reyes (30 miles west-northwest of San Francisco) (Fig. 2). In 1984, 586 setnet permits for fishermen were issued from Monterey and Menlo Park. From these, 120 permits were randomly selected and classified by surname as belonging to either the Vietnamese (40 permits) or traditional (80 permits) component of the fishery. Attempts to interview Vietnamese fishermen were unsuccessful because of language difficulties; therefore, survey results pertain only to the traditional component of the fishery and should not be used to generalize for the entire fishery.

Phone numbers, addresses, and other information, such as vessel locations or fishing companies, were gathered for traditional fishermen from the CDFG, processors, harbor masters, and fishermen's associations. Attempts were made to contact fishermen by phone or in person at their home port or buyer.

Vessel values were obtained from the vessel captains. Some captains felt their current wooden vessels could be replaced more cheaply with new steel vessels. When a captain stated the above, the lesser cost of a steel vessel was used to represent replacement value. The sample was expanded by the formula: Total number of permits (586) times the percentage of traditional fishermen in the sample (80/120) times the percentage of active traditional fishermen (27/80) in the sample [(586) (0.67) (0.34) = 132.51 $\sim$ 133] equals the number of active traditional permittees in the study. The vessel price actually paid was adjusted by the Consumer Price Index to represent the value of the 133-vessel fleet in 1984.

To determine the annual mortgage cost associated with this fleet required three steps. The first and second steps determined the sampled fleet's value and expanded this figure to the entire fleet. The third step required assigning one mortgage rate to the entire fleet value. This assumed that this value would prevail for all vessels, and that all vessels would have a 10-year mortgage. After discussion with persons familiar with marine vessel mortgages and lending institution mortgage rates in central California, a rate of 12 percent[2] was felt to be a usable estimate.

Results

Who Was Contacted

As mentioned, attempts were made to contact only the traditional, non-Vietnamese fishermen. Of these 80, 16 permittees (20 percent) could not be located; 64 (80 percent) were contacted. Thirty-seven fishermen (46 percent) were not fishing setnets in the ocean between Point Sal and Point Reyes in

[2]Personal communication with George Grundig, George M. Grundig and Assoc., 61 Moraga Way, 5, Orinda, CA 94563; and Michael Penzer, Bank of America, Box 37000, San Francisco, CA 94137.

1984. Twenty-seven fishermen (34 percent) were active in that area; however, only 23 (85 percent) of the 27 active fishermen were interviewed. One fisherman declined to be interviewed, and three were unavailable due to location or health. The following results and comments are based on the products of these 23 interviews and may not be representative of the entire traditional fleet nor are they in any way an indication of the magnitude of the Vietnamese setnet fishery in proportion, size or value.

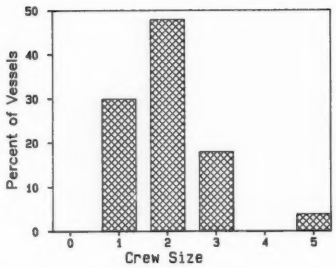


Figure 3.—Crew size (includes captain) of traditional central California setnet vessels in 1984.

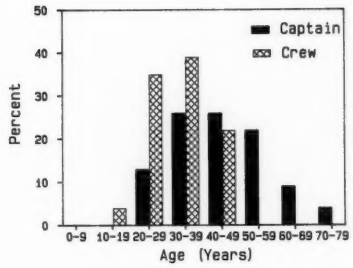


Figure 4.—Ages of captains and crew members on traditional central California setnet vessels in 1984.

Demographics of Fishermen

All except one of those interviewed were vessel captains. Three-fourths of them (17) were sole owners of their vessels, 8 percent (2) partly owned their vessels, and 17 percent (4) were nonowners. Crew size (including captain) averaged two people per vessel (range one to five). Vessels without crews (captain only) represented 30 percent of the fleet, 48 percent had two people, 18 percent had three, and 4 percent of the vessels had five people (Fig. 3).

Captains and crews of the vessels exhibited differences in age, education, and fishing experience. Captains averaged 45 years of age, with 14 years of education and 20 years of fishing experience. Crewmen averaged 31 years of age (Fig. 4), with 12 years each of education (Fig. 5) and fishing experience (Fig. 6). Over 80 percent of captains and crews were high school graduates. Forty-four percent of the captains had a post-high school education and 18 percent had a postgraduate education. Thirteen percent of the crewmen had post-high school education and none had postgraduate education.

One of the interesting aspects of the setnet fishery is the relationship between crew and captain. Most crewmen obtained the majority of their fishing experience with their current captain and averaged 7 years with this captain. Time spent with current skipper ranged from 1 to 26 years (Fig. 7), with 65 percent having had between 1 and 6 years with the current captain. The remaining 35 percent had been with the captain over 10 years. Sons of captains represented 13 percent of the total crewmen, and cousins 9 percent. All related crew members' fishing experience was gained with their relative and this experience averaged 10 years. The 78 percent of the crewmen not related to the captain averaged 6 years experience. Unrelated crew members who had fished with only one captain (17 percent of the total) averaged 2 years fishing experience. The unrelated crew members who had fished with more than one captain (61 percent of the total) averaged 8 years fishing with their current captain.

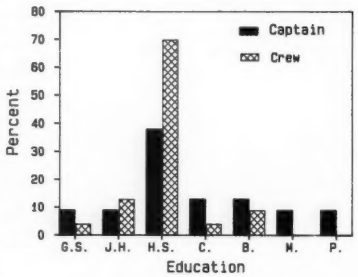


Figure 5.—Education of captains and crew members on traditional central California setnet vessels in 1984. G.S. = 3rd-8th grade; J.H. = 9th-11th grade; H.S. = high school; C. = some college; B. = bachelor's degree; M. = master's degree; P. = doctorate.

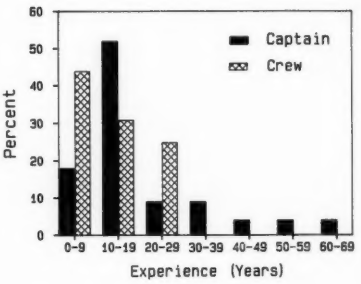


Figure 6.—Experience of captains and crew members on traditional central California setnet vessels in 1984.

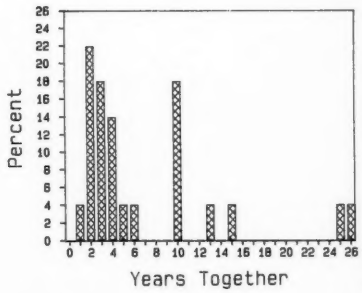


Figure 7.—Years captains and crew members on traditional central California setnet vessels have fished together through 1984.

Gear Characteristics

Fishermen often fish with different nets during a given year. Neither the type of nets used nor the combination of nets appears to be related to fishermen's experience. Less than 10 percent of the fishermen stated that they fish with different types of nets during one trip. Seventy percent of the fishermen fish gill nets, 35 percent with trammel

nets, and 43 percent with suspender nets. The total percentage exceeded 100 because some used more than one gear. Sixty-one percent used one gear only: Gill (35 percent), trammel (13 percent), and suspender (13 percent). Dual gear use was: Gill and trammel, 9 percent; gill and suspender, 17 percent; trammel and suspender, 4 percent; and all three net types, 9 percent.

Gill nets were grouped into three mesh-size categories: Small, 2⅛-3 inches; medium, 4¼-4⅝ inches; and large, 6-9 inches. The small-mesh nets are used to fish white croaker. The average effective fishing height of these nets (distance from floatrope [corkline] to footrope [leadline] when set) is 12 feet. The medium-mesh nets have an effective fishing height of between 12 and 18 feet and are used to fish rockfish, lingcod, and sablefish. Gillnets with the largest mesh have an effective fishing height of 16-22½ feet, and are used to catch rockfish, lingcod, starry flounder, *Platichthys stellatus*; and other flatfishes. These nets also can catch halibut and sharks, but are not considered optimal for these species.

Trammel nets have 8- to 10-inch mesh in the inner walls (81 percent were 8-inch) and 14- to 36-inch outer wall mesh (27 percent were 24-inch and 27 percent were 32-inch). The effective fishing height of these nets range from 6 to 18 feet (45 percent fished 18 feet). These nets are used to catch halibut, soupfin shark, *Galeorhinus zyopterus*, and other sharks, but rockfish, lingcod, and crabs are also caught.

Suspender nets have mesh sizes ranging from 7½ to 9½ inches, with 63 percent either 8 or 8½ inches. Effective fishing height ranges from 6 to 16 feet (30 percent fished 10 feet and 20 percent fished 15 feet). These nets are used to catch halibut, sharks, and rockfish, but other large fish are also caught.

Setnet netting is monofilament nylon and three-strand twisted nylon. Braided nylon was not being used, nor was multifilament nylon, although some fishermen indicated that they were going to build some multifilament nets, because of reports of less loss of captured fish.

All trammel nets were constructed of twisted three-strand nylon ranging in size from size 8 (0.038-inch diameter, 75-pound test) to size 16 (0.056-inch diameter, 135-pound test). Ninety percent of all suspender-net mesh was constructed of monofilament line from size 69 (19-pound test) to size 139 (28-pound test). Roughly half of the gill-net mesh was monofilament and the other half twisted three-strand nylon. Monofilament size was from 19-pound to 60-pound test line, while three-strand was between 50-pound and 170-pound test.

Anchors varied in type and weight among and between net types. The fishermen reported choice of type and weight to be a function of depth of water, length of net, time of year, and area of fishing.

Gill nets had the largest variety of anchor types (seven) and the largest weight range (24-90 pounds). The seven anchor types were Danforth[3] (35 percent), stock (23 percent), Northrop (12 percent), rocks (12 percent), cement blocks (6 percent), window heights (6 percent), and kedge (6 percent). Anchors used by trammel-net fishermen were the most homogenous: Danforth (80 percent), Northrup (10 percent), and kedge (10 percent).

Weight of trammel-net anchors ranged from 40 to 55 pounds (chain included). The average anchor weighed 51 pounds and 60 percent of the anchors weighed 55 pounds.

Suspender-net fishermen used Danforth or Northrop anchors 87 percent of the time and stock anchors the rest of the time. Anchors averaged 44 pounds and weights ranged from 30 to 80 pounds.

It appears that trammel-net fishermen have developed a coastwide consensus on the type and range of weights most suited for that gear. Suspender-net fishermen have the second smallest variance in anchors and appear to be adopting two types of anchors which weight about 40-45 pounds. Gill-net anchors, on the other hand, show no trend in type or weight. Fishing experience of the captain appeared to have little to do with either the anchor type or weight.

[3]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

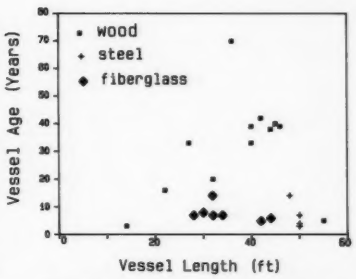


Figure 8.—Age of vessels vs. length relationship in the traditional central California setnet fishery in 1984.

All fishermen assembled their own nets. This generally requires the fishermen to attach premade netting or web to the footrope and floatrope and to attach bridles to the net for anchor, buoy, and flag. The fishermen's average annual assembly time for gill nets was 150 hours and for suspender and trammel nets 185 hours each. The gill net takes less time because only one item is attached to both foot- and floatropes.

Although obvious correlations were not found between types of setnet gear and fishermen's experience, age, or education, the gear used and the construction material of the vessel appeared to be correlated. Vessels were constructed of three materials: Wood (52 percent), fiberglass (30 percent), and steel (18 percent). Three-fourths of the wooden vessels were equipped with trammel and suspender nets and 58 percent with gill nets. Fiberglass and steel vessels were equipped with gill nets 82 percent of the time and trammel and suspender nets 55 percent. Vessel construction material was also correlated to vessel age. Wooden vessel ages ranged from 3 to 70 years, with an average of 31 years and a mode of 35. Fiberglass vessel age ranged from 5 to 14 years, with an average of 8 years and a mode of 7 years. Steel vessel ages ranged from 3 to 14 years with an average of 7 years and a mode of 6 years (Fig. 8). No significant correlation (r = 0.36; P = 0.08; n = 23) was found between vessel age and horsepower, but roughly three-fourths of the wooden and fiberglass vessels had diesel engines; the remainder were gasoline. All the steel vessels had diesel engines.

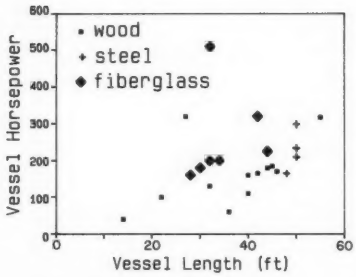


Figure 9.—Horsepower of vessels vs. length relationship in the traditional central California setnet fishery in 1984.

Engine horsepower averaged 155 for wooden, 227 for steel, and 256 for fiberglass vessels, but horsepower was not significantly correlated with vessel length ($r = 0.28$; $P = 0.19$; n = 23) or engine used (Fig. 9).[4] The hold capacity varied by construction material, with wooden vessel capacities averaging 13 tons (range from 0 to 30), fiberglass vessels 6 tons (range from 0 to 18), and steel vessels 28 tons (range from 15 to 30). No other obvious correlations between vessel characteristics, personnel, or gear were observed.

Characteristics of Fishing Operations

Many things affect the fishing operations of the setnet fishery. Included in these are fishing methods, kinship among fishermen, coastal mobility, and costs of fishing.

Fishermen using setnets off central California vary the length of time the nets are soaked, trip time, number of nets, length of nets, and method of fishing. These differences are in response to the species of fish being sought, weather conditions, vessel size, and time of the year. Most fishermen (96 percent) do not combine fishing methods during one trip. The remaining fishermen would use setnet and other gear, such as hook and line or traps. About one-fifth of the fishermen interviewed tended their nets and stayed in the area where the nets were set; the remaining fishermen (80 percent) set their nets and returned to port. Nets were generally set one day and pulled the next. Less than 10 percent of the vessels intentionally soaked the net longer than a day. When weather was bad, some nets would remain set until it was safe to retrieve. Fishermen generally avoided setting the net if the weather was too bad to retrieve or was believed to be turning bad. Trip length varied from 3 to 120 hours. A breakdown of trip length showed that almost two-thirds of the fishermen made trips of less than 2 days (0-12 hours = 18 percent; 12-24 hours = 23 percent; 24-48 hours = 23 percent). Eighteen percent of the fishermen made 3-day trips, 13 percent made 4-day trips, and 5 percent made 5-day trips.

Kinship is often an important aspect of a fishery and 70 percent of the captains in the setnet fishery had relatives in the fishing industry. All were male. Almost all of these relatives were fishermen, and most of them fished in central California. The remaining kin worked in the processing, wholesaling, or retailing sectors of the industry. Some fishermen purchased fish from other fishermen, and a few of these also processed fish for resale. A few purchased fish from other fishermen for another buyer, and some worked for a particular processor.

Mobility among fisheries and with a single fishery may decrease economic risk, allowing owners to fish where they believe economic returns will be the largest. Fishermen were asked to name their three most important fisheries. Seventy percent reported three fisheries, while 26 percent of the fishermen had participated in only two fisheries, and 4 percent in only one. Eleven fisheries were mentioned and the three most often reported were setnet fisheries for halibut (65 percent), Pacific herring, *Clupea harengus* (48 percent), and rockfish (42 percent). A total of six setnet fisheries was reported; the other three were shark (13 percent), white croaker (9 percent), and Pacific ocean perch, *Sebastes alutus* (4 percent). Other fisheries reported were round haul fishing with a lampara net for squid (13 percent) and chub mackerel, *Scomber japonicus* (13 percent), trolling for Pacific salmon, *Oncorhynchus* spp. (30 percent), trapping for Dungeness crab, *Cancer magister* (22 percent), and drift gillnetting for swordfish, *Xiphias gladius* (4 percent).

Other gear used by 96 percent of the setnet fishermen was hook and line (70 percent-troll, longline, or pole), lampara net (30 percent), pots (20 percent—crab), and trawl (4 percent).

Setnet vessels not only fish in other fisheries and use other types of gear, but they also land at many different ports. Setnet fishermen in 1984 landed fish at only one port (22 percent of the fishermen), two ports (35 percent), three ports (31 percent), four ports (4 percent), five ports (4 percent), and six ports (4 percent). Landings were recorded in all ports from Bodega Bay to Avila Beach. Seventy percent of the vessels made landings in San Francisco, twice the percentage of any other port in the study area (Fig. 10).

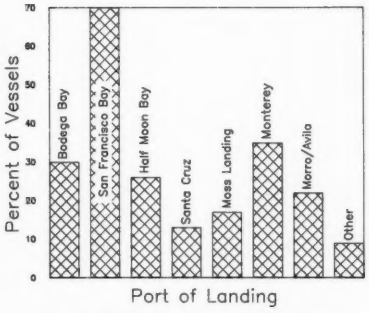


Figure 10.—Percentage of setnet vessels making landings in central California in 1984. Percentages do not equal 100 because vessels landed in more than one port.

Cost and Earnings

The costs of fishing are divided into two categories—fixed and variable. Fixed costs here include only the mortgage cost of the vessel. Variable costs include annual maintenance, repair and replacement of fishing nets, food, fuel, ice, insurance, vessel repair, vessel improvements, moorage, bookkeeping, and miscellaneous services. Crew remuneration could not be calculated from

[4]When one observation was excluded, a significant correlation was found between vessel horsepower and length ($r = 0.49$: $P = 0.02$, n = 22).

the data available.

Vessels' fixed costs were obtained by asking captains how much they actually paid for their vessels, how much they would sell their current vessel for, how much they would pay for a similar vessel, and how much it would cost to replace their vessel with a similar new one. The actual price and the willing-to-pay and willing-to-sell prices were all estimated to be near $10,000,000. This price is used as the surrogate for the total value of the 133 vessels in the calculated traditional fleet. The replacement price for the same vessels was estimated to be $15,000,000.

Fifty-seven percent of the surveyed vessels are mortgaged. Mortgages are held by private institutions (17 percent of all vessels), backed by government-guaranteed loans with private institutions (13 percent), or entail personal loans from relatives (17 percent) (no response 10 percent). Interest rates ranged from 8 to 13.2 percent, but 26 percent of all loans had no interest charge. These zero-interest loans required repayment in 2-4 years on a predetermined payment system. As previously noted, the traditional setnet fleet is valued at $10,000,000. If the entire fleet were mortgaged at 12 percent with a 10-year loan, the vessel owners would have an annual fixed cost of $1,750,000.

Although the total amount of the crews' remuneration could not be evaluated, the method was determined. Remuneration of setnet fishermen was generally on a lay (share) basis, which varied by vessel, area, ownership, fishery, and value of landing. Sixty percent of the fishermen were paid on a share of gross revenues, 36 percent on a shore of net revenues, and 4 percent were salaried. Crewmen receiving a shore of the gross revenue averaged 25 percent of the gross (range from 12 to 40 percent). Those receiving a share of the net revenue averaged 24 percent (range from 7.5 to 40 percent). Net revenue was determined by subtracting fuel and food from gross revenue. One vessel divided the food costs among owner and crew. Some crewmen received a higher percentage of the agreed-upon gross or net share when the revenues for the trip were low.

Table 1.—Minimum fixed and variable costs[1] attributed to setnetting in California, 1984.

Item		Costs	
Fixed cost of vessel: 10-year mortgage at 12 percent			$1,750,000
Variable cost of fishing			
Moorage	$ 67,000		
Insurance	264,000		
Repair and other	158,000		
Improvements	115,000		
Fuel	355,000		
		$959,000	
Net material 1984		550,000	
Labor: 31,000 hr @ $8.07/hours		250,000	
Minimum variable cost			1,759,000
Minimum 1984 setnet fishing costs			$3,509,000

[1]Variable costs not included are crew remuneration and miscellaneous costs.

Seventy-eight percent of the captains made their entire income from fishing. The remaining captains earned between 40 and 80 percent of their income from fishing. Setnetting earnings comprised from 2 to 100 percent of captains' earnings, with 30 percent earning between 2 and 19 percent, 26 percent between 20 and 39 percent, 13 percent between 40 and 59 percent, 13 percent between 60 and 79 percent, and 18 percent between 80 and 100 percent.

The 1984 variable costs to the setnet fleet which I could attribute to moorage, insurance, repair, improvements, and fuel was nearly $1 million dollars (Table 1). Nets owned by the fleet were valued at $850,000. The cost of materials used to build or repair these nets in 1984 was $550,000. Building and repairing the setnets owned by the fleet took an estimated 31,000 hours of labor. This work is estimated to be worth $250,000 ($8.07/hour).[5] Other variable costs, such as ice, food, crew remunerations, bookkeeping, and miscellaneous services, could not be estimated from available data and, therefore, the variable cost should be considered a minimum. Minimum variable costs for 1984 would be about $1.8 million and total costs, variable plus fixed, would be about $3.5 million.

[5]Blend of four 1984 hourly rate values. Hourly rate for a moderately-skilled government worker: GS-6 ($7.45), GS-7 (8.28). Weekly Federal Employers News Digest, Vol. 33, No. 36, 16 April 1984, Washington, D.C. Hourly rate for manufacturing total all categories: Humboldt County ($7.62), and San Francisco County ($11.38). 1985 County Business Patterns, U.S. Bureau of the Census, Wash., D.C.

Ex-vessel Revenue

Three problems exist due to the incompatibility of the data base used to determine ex-vessel revenue and the area and scope of the study. One problem was caused because the ex-vessel values in PacFIN[6] for 1984 were not accurately differentiated by gear. Only 19 percent of the fish from the study area in the "net" and "other gear" categories were attributed to the "net" category. In 1985, 59 percent of the fish in these two categories were net-caught. Therefore, the species breakdown from the 1985 report rather than 1984 was used to determine catch by species.

Ex-vessel value estimates from 1984 data were not considered reliable because the "other gear" category accounted for over 90 percent of the landings in the Monterey area. How much of this could have been landed by setnets is not known. However, the total ex-vessel values of the "other gear" and "net" categories for 1984 and 1985 were only 8 percent apart and I believe that the 1985 ex-vessel value breakdown is similar to the 1984 value.

Another problem existed because the study site area was different from the PacFIN data. PacFIN uses the Pacific Marine Fishery Commission areas designated Conception and Monterey. This covers the area from the Mexican/California border north to lat. 40½°30′ N (roughly Cape Mendocino, Calif.). This northern boundary of the Monterey area is 150 n.mi. north of the study area, and the southern border of the Conception area is 260 n.mi. southeast of the study area.

A third problem was that only the traditional fishermen were sampled and PacFIN data covers both traditional and Vietnamese fishermen. The final problem entailed combining price and quantity information for the "other gear"

[6]PacFIN is the Pacific Fishery Information Network data report published by the Pacific Marine Fishery Commission, Portland, Oreg.

Table 2.—California landings of "net" and "other gear" for the Pacific Marine Fishery Commission Monterey and Conception areas, 1984 (PacFIN[6] Report #009 and 054, 14 February 1985).

Species	Other gear Qty. (mt)	Other gear Price ($/kg)	Other gear Value ($K)[1]	Net Qty. (mt)	Net Price ($/kg)	Net Value ($K)	Combined total Qty. (mt)	Combined total Value ($K)
Flatfish	60	$.93	$56	52	$1.00	$52	112	$108
Rockfish	1,804	.91	1,632	2,893	.84	2,425	4,697	4,057
Lingcod	171	.73	124	99	.69	68	270	192
Sablefish	307	.68	210	33	.46	15	340	225
Other	1	.71	1	1	.63	1	2	2
Misc. groundfish	37	1.76	65	128	1.55	198	165	263
California halibut	73	4.11	300	421	4.04	1,700	494	2,000
Total			$2,388			$4,459		$6,847

[1]K = 1,000.

Table 3.—Estimated[1] ex-vessel revenue attributed to traditional setnet fishermen in central California, 1985.

Species	Landings by other gear Value[2] ($K)	Landings by other gear Setnet (%)	Landing values Gear ($K)	Landing values Other net ($K)	Landing values Total setnet ($K)	Value of traditional setnet fishery % Total[4]	Value of traditional setnet fishery
Calif. halibut	$300	100	$300	$1,700	$2,000	100	$2,000
Flatfish	56	80	45	52	97	90	87
Rockfish	1,632	50	816	2,425	3,241	50	1,621
Lingcod	124	50	62	68	130	50	65
Sablefish	210	50	105	15	120	35	42
Other	1	50			1	100	1
Misc. groundfish	65	50	32	198	230	70	161
Total							$3,977

[1]Author's estimate; see text for other estimates.
[2]K = 1,000.
[3]Percentage of PacFIN report estimated to be made by setnets in study area from the "other gear" category.
[4]Percentage of adjusted landings attributed to traditional setnet fishermen.

category. Precision is lacking because only some of the fish in the "other gear" category were believed to be net-caught, and a price differential may have existed among gears within the "other gear" category.

The incompatible PacFIN and study data were adjusted after discussions with groundfish biologists[7] and industry people familiar with the breakdown of landings. The largest adjustments were to the rockfish in the PacFIN "other gear" category north of Bodega Bay and the sablefish and rockfish caught south of Santa Maria. Total value for these areas before adjustments was $6,847,000 (Table 2). Final estimates which have been adjusted for area, other gear landings, and Vietnamese landings resulted in an ex-vessel value for the traditional setnet fishermen of central California of $3,977,000 (Table 3). Due to the many adjustments, this figure was rounded to $4,000,000. Other scientists and fishermen were also contacted and their suggested adjustments resulted in total ex-vessel revenues of $4,309,000, $4,274,000, $4,070,00, and $3,776,000.

[7]F. Henry, personal communications, California Department of Fish and Game, Menlo Park, Calif. K. Worcester and J. Richards, Sea Grant Advisors, Port San Luis, Calif.

Conclusion

The traditional sector of the central California setnet fishery was calculated to support a highly educated and experienced group of 266 fishermen, fishing from 133 vessels for many different kinds of fish. The estimated cost, excluding crew remuneration and miscellaneous costs of the setnetting, is in excess of $3.5 million and the fishery produces an ex-vessel revenus of around $4 million. Setnet revenues represented an estimated 41 percent of the captain's total earnings from fishing in 1984. The value of vessels and setnet gear was about $11 million.

Acknowledgments

The author would like to thank California Department of Fish and Game for their direction, advice, and assistance, especially Paul Wilde, Chuck Haugen, Frank Henry, and Tom Jow. A special thanks goes to the California Marine Advisory Program (MAP) which designed the survey document, conducted the interviews, and then graciously provided me with the data. This study would not hve been possible without the following MAP personnel: Constance Ryan, Karen Worcester, and Edward Melvin.

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U.S.-U.S.S.R. Discuss Bering Sea Fisheries

United States and Soviet fisheries delegations met in Washington, D.C., 18-22 April to discuss a broad range of fisheries issues of mutual concern. The U.S. side was headed by Ambassador Edward E. Wolfe, Deputy Assistant Secretary for Oceans and Fisheries Affairs, U.S. Department of State. The Soviet side was headed by V. K. Zilanov, U.S.S.R. Deputy Minister of Fisheries.

Both delegations characterized the talks as highly productive. Pursuant to the undertakings to improve fisheries relations contained in the Joint U.S.-Soviet Summit Statement made by President Reagan and General Secretary Gorbachev on 10 December 1987, in Washington, D.C., and the joint statement made by Secretary of State Schultz and Minister of Foreign Affairs Shevardnadze during their negotiations in February 1988, in Moscow, the two delegations considered possible ways for the two sides to act together on a wide range of issues related to conservation, rational utilization, and management of living marine resources.

Pursuant to understandings reached in Moscow in January 1988 to form a Bering Sea fisheries working group (see article below), the two delegations discussed the conservation aspects of Bering Sea fisheries in light of the vastly increased level of fishing in the region beyond the respective economic zones of the two states. A full exchange of views was made with regard to the legal, scientific, and enforcement aspects of the Bering Sea fisheries both within and beyond the respective economic zones of both states.

It was agreed that most of the commercially fished species of the Bering Sea are common to the economic zones of the United States and the Soviet Union while stocks of walleye pollock, *Theragra chalcogramma*, range both within and beyond the economic zones of the two states. Both sides expressed strong concerns over the adverse impact of unregulated, large-scale fisheries beyond the economic zones of pollock stocks which are a part of the ecological complex of the Bering Sea.

The delegations agreed on the need to develop further cooperation between the United States and the Soviet Union in the exercise of their rights and duties under international law to coordinate conservation and management of living marine resources of the Bering Sea. In addition, both sides agreed to convene jointly a scientific symposium in the United States in 1988, inviting scientists from all states concerned, to review the status of fishery resources in the Bering Sea, particularly pollock.

The two delegations agreed to continue coordinating the actions of both sides on fisheries of the Bering Sea. The two sides also discussed the implementation of the interim fisheries agreement, signed on 21 February by Secretary of State Shultz and Minister of Foreign Affairs Shevardnadze, regarding U.S. access to the U.S.S.R. economic zone. The two sides also considered the expeditious preparation and conclusion of a comprehensive fisheries agreement between the United States and the Soviet Union to govern their mutual relations in the field of fisheries. This agreement would, among other things, address conservation and management issues related to fishery resources of the Bering Sea, including the area beyond the respective economic zones of both states. Because of the urgency of these issues, the delegations agreed to continue bilateral discussions in Moscow in the near future. (Source: IFR-58/38.)

U.S.-U.S.S.R. Fishery Talks

United States and Soviet fishery delegations met in Moscow during 26-28 January 1988, to discuss a broad range of fishery issues of mutual concern. Both delegations characterized the talks as highly productive. It was agreed that the two sides would soon conclude arrangements allowing access by U.S. fishing vessels to the Economic Zone of the U.S.S.R. on the same terms as the U.S.S.R. vessels now have in the U.S. Exclusive Economic Zone, as provided in the current U.S.-U.S.S.R. Fisheries Agreement.

The two delegations also agreed to immediately form a bilateral U.S.-U.S.S.R. Working Group on Fisheries of the Bering Sea. This group will include legal, scientific, and technical specialists from both sides which will develop recommendations for dealing with increased fishing in the Bering Sea. The talks included finalizing plans for a March industry-to-industry meeting in the Soviet Union to discuss possible fishery commercial joint ventures, and plans to address additional scientific and other issues to improve overall bilateral fisheries cooperation on a mutually beneficial and equitable basis.

U.S. Ends Certification of U.S.S.R. for Whaling

U.S. Secretary of Commerce C. William Verity has announced his decision to terminate the certification of the Soviet Union under the Packwood-Magnuson and Pelly Amendments for its whaling practices. The announcement was made in Moscow on 14 April during a press briefing at the end of the Joint Commercial Council (JCC) meeting, as follows:

"In concluding my remarks, I want to announce that I have received assurances from the Soviet Ambassador to the United States confirming that the Soviet Union has ceased commercial whaling and intends to work through the International Whaling Commission (IWC) for whale research and conser-

vation. The cessation of commercial whaling by whaling nations has been a major objective of global environmental groups and the IWC, supported by the United States. I welcome the Soviet decision and hope that it sets a pattern for similar decisions on the part of other whaling nations to work within the IWC for the purposes of research and conservation. We look forward to cooperating more closely with our Soviet colleagues in the IWC, our fisheries relations, and our broader bilateral agenda."

Secretary Verity sent a letter to U.S. Secretary of State George P. Shultz conveying his decision (see below). A *Federal Register* notice, required by law, explaining the reasons for his decision was also prepared for publication on 14 April (see below). The Secretary of Commerce has withdrawn the certification because the reasons for the April 1985 certification no longer prevail. The Soviet Union has confirmed that it has ceased whaling and intends to work through the IWC for whale research conservation. (Source: U.S. Embassy, Moscow).

Text of letter to Secretary George P. Shultz relating Commerce decision to terminate the certification of the Soviet Union for whaling practices:

Dear George, On April 1, 1985, Secretary of Commerce Malcolm Baldrige certified to the President that Nationals of the Soviet Union were conducting whaling operations that diminished the effectiveness of an international fishery conservation program under the Pelly Amendment to the Fishermen's Protective Act of 1967, 22 U.S.C. 1978 (1983 SUPP.) and the Packwood-Magnuson Amendment to the Magnuson Fishery Conservation and Management Act, 16 U.S.C. 1821 (1983 SUPP.). Following certification and consultations between the Departments of State and Commerce, Soviet fish allocations were reduced by 50 percent and all allocation available to the Soviet Union eliminated one year later. The Pelly Amendment requires periodic review of the basis for certification, and I have recently concluded such a review. I have determined that the conditions that prompted the certification of the Soviet Union no longer exist, and I am terminating the certification under both the Pelly and Packwood-Magnuson Amendments. I recommend that the Department of State promptly notify the Government of the Soviet Union of the termination of the certification. In addition, the National Oceanic and Atmospheric Administration will provide recommendations for fish allocations to be made available to the Soviet Union at the appropriate time. Sincerely, Secretary of Commerce.

Federal Register notice explaining the termination of Soviet certification.

Summary: Notice is published that the Secretary of Commerce finds the reasons for the certification of the Soviet Union, under the Pelly and Packwood-Magnuson Amendments for activities that diminish the effectiveness of an International Fishery Conservation Program, no longer prevail and that the certification has been terminated.

Supplementary Information: Under the Pelly Amendment to the Fishermen's Protective Act and the Packwood-Magnuson Amendment to the Magnuson Fishery Conservation and Management Act, the Secretary is responsible for determining if nationals of a foreign country, directly or indirectly, are conducting fishing operations in a manner or under circumstances which diminish the effectiveness of an international fishery conservation program. If the Secretary of Commerce so determines, such certification is reported to the President. On April 1, 1985, Secretary Malcolm Baldrige certified to President Reagan that the Soviet take of Southern Hemisphere minke whales had diminished the effectiveness of the International Whaling Commission (IWC) conservation program. The Secretary based his determination on the following facts: 2) The Soviet harvest of Southern Hemisphere minke whales was greater than the level the United States considered the U.S.S.R.'s traditional share, 2) The 1984-85 IWC quota for Southern Hemisphere minke whales was exceeded due to Soviet harvest and 3) there had been no indication that Soviets intended to comply with IWC standards.

The Soviet Union has ended its commercial harvest for Southern Hemisphere minke whales and has indicated its intention to cooperate in the conservation of whales within the framework of the IWC. Given that the reasons for the certification of the Soviet Union no longer prevail, the Secretary has terminated the certification under both the Pelly and Packwood-Magnuson Amendments. (Source: IFR-88/31.)

U.S., U.S.S.R. Sign Fisheries Agreement

A comprehensive agreement governing fisheries relations between the United States and the U.S.S.R. was completed on 23 May after a week-long negotiating session in Moscow; it was signed at the Moscow Summit on 31 May. The agreement provides for access by each nation's fishing vessels to surplus fishery resources in the other's Exclusive Economic Zone. Fishing vessels of both nations also can purchase supplies, effect repairs, and exchange crews at specified ports: Boston, Mass., Portland and Astoria, Oreg., and Dutch Harbor, Alaska, in the United States; Murmansk, Provideniya, Korf, and Oktyabrski in the Soviet Union.

The agreement states that the two countries have a common concern for conservation of shared stocks in the Bering Sea and for Pacific salmon, *Oncorhynchus* spp., resources, and will cooperate in data collection and scientific research. The agreement also provides for the establishment of a bilateral consultative committee to meet each year, and for the appointment of a U.S. fisheries attache at the U.S. Embassy in the Soviet Union. As an adjunct to the negotiation of this agreement, the two sides agreed to hold an international scientific symposium on Bering Sea walleye pollock, *Theragra chalcogramma*, resources to be held in Sitka, Alaska, in mid-July, and agreed to coordinate efforts to achieve third-party cooperation in conserving pollock resources.

NMFS Will Enforce Lacey Act in Bahamian Waters

It is illegal to possess fish or lobster taken in Bahamian waters, or to import

them into U.S. jurisdiction, or to sell them in the United States or to a foreign interest, or to attempt to import or sell them, Joseph Angelovic, Acting Southeast Regional Director of the National Marine Fisheries Service announced early this year. The Bahamas exercises fisheries jurisdiction over all waters to the East of the Fishery Conservation Zone/Exclusive Economic Zone line between Florida and the Bahamas depicted on U.S. chart 11460, 28th Edition, Feb. 22, 1986.

To clear up any possible confusion Angelovic stated, let it be known that any U.S. fisherman found fishing in Bahamian waters will be prosecuted by the National Marine Fisheries Service to the fullest extent of the law under the Federal Lacey Act. Penalties for felony conviction are up to 5 years in prison and up to $20,000 fine, plus loss of all fish taken, the vessel, trailer, vehicle, and equipment used to aid in the violation for most violations. Penalties for a misdemeanor conviction are up to 1 year in prison and up to a $10,000 fine, while civil penalties of up to $10,000 penalty per violation can be assessed. For further information or to report violations, contact Eugene Proulx at (813) 893-3145.

U.S. Fishery Export Picture Looks Good

The year 1987 was a banner year for U.S. fish exporters, with total overseas sales of fishery products a record $1.66 billion, up 22 percent over 1986, according to the National Oceanic and Atmospheric Administration (NOAA). NOAA said American joint-venture operations also set records last year. Exports and joint ventures in 1987 together amounted to more than $1.8 billion. Joint ventures are those in which U.S. fishermen sell their catch at sea to foreign processing boats.

According to NOAA economists, if this trend continues, fish sales to foreign buyers will top $2 billion this year, making the United States the world's biggest fish exporter. The volume of the catch rose too, to a record 525,000 metric tons, up 13 percent from 1986, the Commerce Department agency said. And the country's biggest foreign fish buyer, Japan, bought fish and fishery products worth a record $1.074 billion in 1987.

Also in 1987, seafood imports rose by $800 million to a record $5.6 billion. If nonedible marine products are included—mostly high value-added jewelry made with coral or pearls—that import figure increases to $7.9 billion. NOAA says it expects the 1988 balance-of-trade figures to look about the same. Part of the reason for the persistent trade deficit, says NOAA, is that the U.S. fishing industry cannot fully supply America's growing taste for high-priced products like shrimp, tuna, scallops, lobster, and farmed salmon. That demand is being met by imports.

NOAA Moves to Cut Dolphin Deaths

Foreign nations exporting yellowfin tuna to the United States caught in the eastern tropical Pacific Ocean must take steps to reduce the number of dolphins killed during purse seine fishing, the Commerce Department's National Oceanic and Atmospheric Administration (NOAA) announced early this year. Countries that do not reduce dolphin deaths will not be allowed to import yellowfin into the United States.

A new ruling by NOAA's National Marine Fisheries Service, requires foreign fleets that catch yellowfin tuna from purse seine vessels to establish regulations comparable to those required for the U.S. fleet. The ruling, which went into effect in mid-April, requires observers to monitor fishing activities and the use of gear and techniques that minimize harm to dolphins during yellowfin fishing. The ruling also requires that by 1991, the average annual rate of dolphins killed by a foreign fleet in the area is comparable to the yearly rate for the U.S. fleet.

Eight foreign nations, including Mexico, Venezuela, and Ecuador, fish for yellowfin in the eastern tropical Pacific. In 1986 they harvested almost 195,000 tons of fish. More than 46,000 tons, worth an estimated $35 million, was exported to the United States. In the eastern tropical Pacific where schools of yellowfin tuna swim beneath dolphin herds, fishermen search for schools of dolphins as an indication of tuna. The fishermen encircle both dolphins and tuna with huge purse seine nets. Although the vast majority of the dolphins escape or are released by fishermen, a few become entangled and drown.

NOAA Ship *Researcher* Is Renamed *Malcolm Baldrige* to Honor Late Commerce Department Secretary

The NOAA Ship *Researcher*, an oceanic research vessel operated by the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA), was renamed the NOAA Ship *Malcolm Baldrige* on 1 March in honor of the late Commerce Secretary. Mrs. Baldrige participated in the renaming ceremony, hosted by Commerce Secretary C. William Verity, which began at 11 a.m. at the Washington Navy Yard, Pier 1. The ship was renamed *Malcolm Baldrige* in recognition of the late Commerce Secretary's public service to the Nation. Secretary Baldrige died in a rodeo accident 26 July 1987.

The 2,963-ton, 278-foot *Researcher/Baldrige*, the largest east coast ship in NOAA's fleet of 23 research and survey ships, conducts climate research in the Atlantic Ocean and Caribbean Sea. The ship is based at NOAA's National Ocean Service Atlantic Marine Center in Norfolk, Va., and operates out of NOAA's ship support base in Miami, Fla. The ship can carry 82 NOAA Corps officers, civilian crew members, and visiting scientists, and is equipped with a scientific laboratory, sophisticated communications and computer systems, and the latest scientific instruments for making environmental measurements at sea.

The ship was built by the Toledo Plant of the American Shipbuilding Company and launched on 5 October 1968. It has two 1,600-horsepower, geared diesel engines that power twin controllable-pitch screws and a 450-horsepower bow thruster that can be used to move the ship at very slow speeds or hold it steady on a position. With a cruising range of 13,000 n.mi. and a cruising speed of 14.5 knots, the ship can carry

6-month's worth of provisions for extended scientific operations in remote ocean areas, and can remain at sea for more than a month at a time.

New Federal Lobster Regulations Announced

New Federal regulations governing the American lobster fishery became effective on 31 December 1987. These new regulations were developed by the New England Fishery Management Council in cooperation with the lobster-producing states in New England and the Middle Atlantic. The regulations 1) increase the minimum carapace length for lobsters, 2) prohibit the possession of V-notched lobsters throughout the range of the stock, 3) implement a nationwide prohibition on the possession of V-notched and egg-bearing female lobsters and all lobsters smaller than the minimum carapace length taken and retained in violation of the Magnuson Fishery Conservation and Management Act, and 4) revise the gear identification/marketing requirement.

The minimum carapace length is scheduled to be increased from 3 3/16 inches to 3 5/16 inches by increments of 1/32 of an inch per year over a 5-year period. An escape vent size increase is scheduled to take place at the mid-point of the carapace length increases. The new vent size will be compatible with a minimum carapace length of 3 5/16 inches. The industry will be notified before the end of 1988 as to the exact specification of the new venting requirement. Effective dates of the scheduled increases in carapace length are as follows:

Date	Minimum carapace length
1 January 1988	3 1/32 inches
1 January 1989	3 1/4 inches
1 January 1990	Escape vent size to be compatible with a minimum carapace length of 3 5/16 inches
1 January 1991	3 1/32 inches
1 January 1992	3 5/16 inches

Following each length increase, dealers and wholesalers will have a 180-day grace period to dispose of lobsters purchased or received in the prior year which do not meet the new minimum carapace length.

Secondly, these new regulations prohibit nationwide the possession of egg-bearing lobsters, V-notched female lobsters, and lobsters smaller than the minimum carapace length that were taken and retained in violation of the Magnuson Act. The possession prohibition applies to all lobsters found in commerce unless it can be shown that the lobsters were 1) imported, or 2) harvested by a vessel fishing exclusively in state waters, in which case regulations of the state will prevail. Lobsters from a vessel holding a Federal fishing permit, or a state permit that is endorsed for Federal waters, will be presumed to have been harvested from the Federal waters and will be subject to these new Federal regulations.

Lastly, these regulations revise the gear identification/marking requirement to provide increased flexibility. In addition to allowing Federal Permit Holders to use their state gear identification/marking system, the new regulations authorize gear to be marked with a "number assigned by the Regional Director" instead of simply "the Federal Fishery Permit Number." This means that gear may be marked with the vessel's 1) Federal Fishery Permit, 2) Official or Documentation Number, or 3) any number as authorized by letter from the Regional Director. For additional information on these new Federal regulations, contact Carol Kilbride of the National Marine Fisheries Service at (617) 281-3600.

Oyster Resource Disaster Aid

A total of $2.0 million was made available by late last year under the resource disaster provisions of the Commercial Fisheries Research and Development Act (P.L. 88-309) to the states of Delaware, Maryland, New Jersey, and Virginia, to assist in restoring the commercial oyster fisheries in Chesapeake and Delaware Bays, the NMFS Northeast Regional Office reported in December. Continuation of drought conditions experienced by the Mid-Atlantic states resulted in increased Bay salinities and, unfortunately, a favorable environment for spread of the haplosporidian parasite, commonly known as MSX. As a result, high mortalities and reductions of over 40 percent in yield of marketable oysters occurred, and adverse resource conditions could continue through 1990. Activities being conducted by the four states include dredging and planting of oyster shell for propagation purposes, and field trials of disease resistant strains.

Tagged U.S. Salmon Recovered in Greenland

NMFS Northeast Fisheries Center scientists, in cooperation with their Canadian and Danish counterparts, detected 146 coded-wire-tagged Atlantic salmon, *Salmo salar*, among over 25,000 salmon examined at four West Greenland fishing ports during August and September 1987. Of the 146 tagged fish, 82 were of U.S. origin, 19 of Canadian origin, and the rest of European origin (mostly England, Wales, and Ireland). Of the U.S.-origin tagged fish, 77, or 94 percent, were from Maine rivers. These tag recoveries are particularly significant because they represent the first year in which coded-wire-tagged salmon of Maine origin have been available to the West Greenland fishery.

Scientists examined the salmon after the fish had been bought by fish processors, but before the fish had been flash frozen and glazed. Scientists used special metal detectors to identify which salmon had the magnetically coded, 1 mm wire tags imbedded in their skulls. These coded-wire tags, which are undetectable by fishermen and thus necessitate the special sampling by scientists, are now in common use by the salmon-producing countries of the North Atlantic. The United States began applying these tags to 1-year-old salmon (smolts) in 1985.

Marine Debris Conference Slated for Hawaii, 1989

The Second International Conference on Marine Debris is scheduled for 2-7 April 1989 in Honolulu, Hawaii, according to Richard S. Shomura, Chairman. Sponsors are the National Marine Fisheries Service, the Marine Mammal

Commission, and the University of Hawaii's Sea Grant College Program.

Since the first (1984) international "Workshop on the Fate and Impact of Marine Debris," also held in Honolulu, a substantial body of information on the topic has been amassed, heightening scientific, legal, and political recognition of the problem. The second conference, says Shomura, is intended to provide a forum to present and evaluate the various aspects of the problem and potential solutions. Some of the topics to be covered include: New data on the types, amounts, sources, fates, and distribution of marine debris in different ocean areas; existing and potential methods for data collection; nature and extent of impacts on living marine resources; impacts on human health and safety of ships at sea; aesthetic and other impacts on coastal environments; effectiveness and future role of programs educating the public and promoting awareness of the problem; and programs necessary to assess the effectiveness of measures addressing the problem.

Early registration fee is US$125 (US$150 at the conference). Further information for prospective authors and participants is available from Richard S. Shomura, Conference Chairman, NMFS Honolulu Laboratory, 2570 Dole Street, Honolulu, HI 95822-2396 U.S.A. (telephone 808-943-1229; or telegram MDEBRIS; or Telex 6503504141 MCI UW).

Mackerel Spawn Heavily North of U.S. Border

Spawning by Atlantic mackerel, *Scomber scombrus*, was more intense in Canadian waters than in U.S. waters during the 1987 spawning season. That's a preliminary observation resulting from eight egg-and-larval surveys conducted by NMFS Northeast Fisheries Center scientists during late spring and early summer as part of a cooperative U.S., Canadian, and Polish effort to estimate the spawning stock biomass of Northwest Atlantic mackerel.

Detailed analysis of the surveys' samples and data shows that spawners in Canadian waters accounted for 89 percent of the adult spawning biomass; spawners in U.S. waters accounted for 11 percent. The Center's estimate of 1987 adult spawning biomass—based on these egg surveys—is 1.10 million metric tons (2.47 billion pounds). This estimate compares very favorably with estimates based on virtual population analysis.

Northwest Atlantic mackerel total stock biomass, as estimated by virtual population analysis, has fluctuated widely over the past 25 years. (Estimates of total stock biomass will always be somewhat larger than estimates of adult spawning biomass since the former includes all age 1 and older fish, whereas the latter includes hardly any age 1, a variable proportion of age 2, and almost all age 3 and older fish.) Total stock biomass increased from 0.30 million metric tons (0.67 billion pounds) in 1962-65 to 1.9 million metric tons (4.26 billion pounds) in 1970-71, decreased to an average of 0.49 million metric tons (1.09 billion pounds) in 1977-81, and increased to 1.50 million metric tons (3.36 billion pounds) in 1986.

Fish Processing Waste Effective as Fertilizer

NMFS Gloucester Laboratory experiments show that fish hydrolysate (a liquified fish mixture derived from the solid wastes of fish processing) is an effective plant fertilizer. This finding offers a possible solution to the recurring problem encountered by fish processors on how to dispose effectively, efficiently, and safely of the solid wastes from fish processing operations. This problem currently limits the restoration, maintenance, or growth of several commercial fishing ports in the U.S. northeast region.

Scientists compared fish hydrolysate that was made from Atlantic cod, *Gadus morhua*, "frames" (what's left after filetting) and that roughly had a 3-5-1 fertilizer value (percent content of nitrogen, phosphorous, and potassium), with a well-known commercial fertilizer with a stated 20-20-20 value. Under controlled but variable conditions of soil type, fertilizer concentration, and fertilization frequency, the fish hydrolysate increased yields in the test crop—greenhouse jalapeno peppers—from 20 to 123 percent.

Cooperative Ocean Cruise Seeks Data on Armorhead

Scientists from the NMFS Southwest Fisheries Center's Honolulu Laboratory returned in February from a 30-day cruise aboard the *Townsend Cromwell* collecting biological and oceanographic information from waters over and surrounding the Southeast Hancock Seamount, which is located about 200 n.mi. northwest of the Hawaiian Archipelago and just within the U.S. 200-mile Exclusive Economic Zone (EEZ).

"From a historical standpoint, the results would hopefully provide valuable insight into what once was a viable commercial fishery for Soviet and Japanese fishing ventures," said Richard S. Shomura, Director of the NMFS Honolulu Laboratory. Shomura added that the seamounts provided habitat for large concentrations of fishes, in particular the target species of fish known as the pelagic armorhead. In the spring of 1985, when armorhead were nearly exhausted by the fishing pressure applied by foreign vessels, the NMFS closed the seamounts within the EEZ to all foreign fishing. The Honolulu Laboratory has since continued to monitor and explore the dynamics associated with abrupt topographical features such as the seamounts present. Chief Scientist Michael P. Seki reported that fishery operations on the cruise involved primarily bottom longlines and bottom trawling gear. Collection of oceanographic data involved sampling along predetermined transects with such equipment as an acoustic Doppler current profiler, a geomagnetic electrokinetograph, hydroacoustic echo sounders, various small nets, etc.

In addition to Seki, scientific personnel on the cruise were research assistants Russell Y. Ito, Frank A. Parrish, Dennis Therry, and Christopher D. Wilson. Also participating on the cruise were cooperating scientists Jed Hirota and James Finn from the University of Hawaii Department of Oceanography, and Peter Koske and Thorsten Knutz from Kiel University in the Federal Republic of Germany.

Predation Limiting Hard Clam Production

Predation substantially limits the production of hard clams in Great South and Barnegat Bays, the largest clam production areas in New York and New Jersey, respectively. These findings come from separate field studies of these areas by NMFS Northeast Fisheries Center scientists, supplemented by laboratory experiments also conducted by the Center.

The Barnegat Bay field study was conducted in conjunction with a cooperative effort to create hard clam spawning sanctuaries throughout the Bay. At each of five study sites, scientists planted paint-marked juveniles (5 mm long) clams around stakes. At four of the five sites, there was at least 62 percent mortality of marked clams within 70 days, with most of it due to crab predation, although at one of those four sites, almost half of the predation was due to oyster drills. In the most extreme case, 96 percent of the marked clams at one site were crushed after four days, indicating crab predation.

In the Great South Bay field study, a scuba-deployed hydraulic suction sampler was used to collect clams at four sites in August 1986, and at six sites in August 1987. This 2-year effort permitted scientists to follow the mortality and growth of the Bay's strong 1985 "set" of clams. Between 1986 and 1987, the average density of these clams decreased from ten to three per square yard. We attribute the mortality largely to predation, mostly by crabs. (Incidentally, in 1987, when the 1985-set clams were 5-20 mm long, we found no other abundant size classes less than 40 mm long. Consequently, clam harvests in the Bay should decrease for 2 or more years until the 1985-set clams grow to a commercial size.)

Scientists also ran a laboratory experiment to evaluate the predation potential of sand shrimp and grass shrimp—which are often abundant on clam beds—on early-stage juvenile hard clams. Individual shrimp were placed in dishes which held 50 1 mm-long clams. In every case, all clams were consumed in 24 hours. The results of the field studies and laboratory experiments show the importance of predation in limiting hard clam production in the New York-New Jersey area.

Toxic Mackerel Liver Eyed in Whale Deaths

In response to the known deaths of 14 humpback, 4 minke, and 2 fin whales along the New England coast in December and January, the NMFS Northeast Fisheries Center began testing the toxicity of liver extracts from several fish species known to be prey—as juvenile or adults—of whales. On 18 December 1987 Center scientists found liver extracts from Atlantic mackerel to be toxic to laboratory test mice. Subsequent evidence gathered by the Center and other organizations has now implicated the consumption of mackerel containing paralytic shellfish toxins in the whale deaths.

Relatively low levels of toxicity were found in all mackerel liver extracts from samples collected within the western Atlantic range of this species (i.e., from Northumberland Strait in the Gulf of St. Lawrence to the Mid-Atlantic region). Mean toxicity levels were 185 μg of toxin per 100 g of liver, with up to 446 μg/100 g present in some samples. Interestingly, scientists found toxicity levels of 60 μg/100 g in liver extract from mackerel stomachs collected off Nantucket Island as long ago as April 1986. It is emphasized, however, that there is no danger to human consumption of mackerel as no toxicity has been detected in the muscle tissue, the edible portion.

No toxicity has been detected in the livers of other whale prey species such as Atlantic herring and silver hake (whiting), nor in the liver of goosefish (monkfish). Stomach contents of one whale—consisting mostly of bones—were tested and found to be only mildly toxic, causing delayed death of mice.

Baseline Established for 12-Mile Dumpsite

The NMFS Northeast Fisheries Center has now completed the first year and a half of sampling at the New York Bight's 12-Mile Dumpsite. The sampling to date has been designed to establish a baseline for determining the effects—primarily biological—of ending sewage-sludge dumping at the site. (The last dumping was in December 1987.)

With a year and a half of sampling completed, scientists can now begin to compare any seasonal trends. During the November survey of three stations, chosen to represent impacted, enriched, and less polluted habitats, some trends persisted from autumn 1986 to autumn 1987. The dominant bottom fishes were little skate (75 percent of the weight tow in 1986; 50 percent in 1987) and winter founder (19 percent in 1986; 15 percent in 1987). At the "impacted" station, the average weight per tow for all bottom fishes increased from 22 to 40 pounds. The dominant crustaceans were rock and horseshoe crabs which ranked first and second, respectively, in weight per tow for both 1986 and 1987. At all three stations though, the weight per tow decreased for both species between the two years.

These early comparisons, however, do not statistically indicate that any rapid significant shift from crustaceans to fishes has occurred. Continued sampling will be necessary to determine if any changes in the biological community in and around the site are related to the ending of sewage-sludge dumping.

Scientists Studying Seafloor Megaplumes

National Oceanic and Atmospheric Administration (NOAA) scientists are studying the origins of a geological process that sends massive amounts of hot fluids into the ocean from cracks in the seafloor. Called megaplumes, the rich, hot soup of mineral grains and dissolved minerals and gases can be miles wide and may have a major influence on ocean chemistry, according to Edward T. Baker of NOAA's Pacific Marine Environmental Laboratory in Seattle, Wash. The Commerce Department scientist said the process, caused by tectonic or volcanic activity suggests a geologic activity different from that which causes the continuous leaking of hot fluid from seafloor thermal vents.

The existence of the process was suggested a year ago when researchers aboard a NOAA ship, investigating seafloor venting along the Juan de Fuca Ridge off the Washington and Oregon coasts, discovered a huge, circular plume of hot water floating deep in the ocean. It was about 10-12 miles in diameter and more than a quarter-mile deep. Last September, again over the Ridge, investigators found a recurrence of megaplume activity.

"It closely resembled the original megaplume, formed by the expulsion over a period of a few days of hundred of millions of tons of superheated seawater from seafloor cracks," Baker said. Since September, he and colleagues Gary Massoth and Richard Feely have analyzed samples from the megaplume, finding them rich in silica, manganese, and iron leached by hot seawater from rocks in the ocean crust. They believe the phenomenon could be common in ocean areas where the seafloor is similar to that of the Pacific ridge.

Juan de Fuca Ridge is a seafloor spreading center where lava from the earth's core rises to form a new ocean crust as the North American and Pacific crustal plates separate. This seafloor spreading creates slow, steady venting of superheated seawater at many locations in the area. The program, called Vents, has studied the phenomenon for 3 years to understand its effect on ocean chemistry. The program operates at the Hatfield-Oregon State University Marine Science Center in Newport, Oreg.

1986-1987 Warmest Years Since 1953

The years 1986 and 1987 were the warmest two years in the contiguous 48 states since 1953, with only three fractionally warmer years this century (1934, 1931, and 1921), according to scorekeepers at the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC), Asheville, N.C. Average annual temperature for the two years was 54°F. Back-to-back warm years last occurred in 1953-54, with average temperatures of 54.7 and 53.9 degrees. The spring of 1986 was warm throughout the 48 contiguous states. The warmth of 1987 was especially noteworthy during the winter of 1986-87 and the spring of 1987 in the north central portions of the country, the Commerce Department agency reports.

Following is a breakdown by regions comparing each season of the recent two-year period with NCDC's records going back to 1895. Regions consist of the following states: West (W) = California and Nevada; Northwest (NW) = Idaho, Oregon, and Washington; Southwest (SW) = Arizona, Colorado, New Mexico, and Utah; West North Central (WNC) = Montana, North Dakota, Nebraska, South Dakota, and Wyoming; and South (S) = Arkansas, Kansas, Louisiana, Mississippi, Oklahoma, and Texas; East North Central (ENC) = Iowa, Michigan, Minnesota, and Wisconsin; Central (C) = Illinois, Indiana, Kentucky, Missouri, Tennessee, West Virginia, and Ohio; Southeast (SE) = Alabama, Georgia, Florida, North Carolina, South Carolina, and-Virginia; and Northeast (NE) = Connecticut, Delaware, Massachusetts, Maryland, New Hampshire, New York, Pennsylvania, Rhode Island, Vermont, Maine, and New Jersey.

Seasons are defined as: Winter = December, January, and February; Spring = March, April, and May; Summer = June, July, August; Fall = September, October, and November.

	Winter 1985-86	Spring 1986	Summer 1986	Fall 1986
W	2nd warmest	7th warmest	12th warmest	21st coldest
NW	41st coldest	11th warmest	6th warmest	41st coldest
SW	4th warmest	4th warmest	22nd warmest	24th coldest
WNC	22nd warmest	4th warmest	18th warmest	20th coldest
S	25th warmest	7th warmest	42rd warmest	42nd coldest
ENC	24th coldest	5th warmest	37th coldest	22nd coldest
C	27 coldest	9th warmest	40th warmest	39th warmest
SE	40th coldest	36th warmest	9th warmest	8th warmest
NE	37th coldest	6th warmest	15th coldest	17th coldest
	Winter 1986-87	**Spring 1987**	**Summer 1987**	**Fall 1987**
W	40th warmest	5th warmest	42nd warmest	3rd warmest
NW	28th warmest	4th warmest	30th warmest	2nd warmest
SW	36th warmest	28 warmest	42nd coldest	24th warmest
WNC	the warmest	3rd warmest	35th warmest	12th warmest
S	35th warmest	42rd coldest	36th coldest	27th coldest
ENC	the warmest	2nd warmest	9th warmest	45th warmest
C	25th warmest	7th warmest	13th warmest	27th coldest
SE	41st coldest	33rd coldest	7th warmest	12th coldest
NE	42nd warmest	9th warmest	25th warmest	22nd coldest

Crab Analog Made From Pacific Whiting Surimi

The Utilization Research Division of the NMFS Northwest and Alaska Fisheries Center reports that it has successfully processed crab analog using Pacific whiting surimi. The surimi was produced during August and October 1987 using ocean-caught fish, and was processed into the analog in a production run at a commercial plan in January 1988. Successful production of the crab analog was made possible by the

incorporation of an inhibitor for the protease enzyme(s) present in Pacific whiting parasitized by the myxosporean *Kudoa* sp. The run of analog in the commercial plant consisted of 100 percent Pacific whiting surimi. No processing problems were encountered in any of the production steps.

Acceptability of the finished product is comparable to product prepared from Alaska pollock surimi. The product has been served to several groups familiar with the technical properties of surimi and analog products. One of these groups was the Pacific Fisheries Technologists at the annual meeting in February 1988. Without exception, everyone that tasted the product agreed that it is excellent and completely acceptable. This demonstrates the feasibility of using Pacific whiting for surimi from which crab analogs and similar type products can be fabricated.

A common method of measuring the quality of surimi for use in analog preparation is to determine gel strength of kamaboko prepared from the surimi. The gel strengths of kamaboko prepared from the two lots of surimi used in this commercial run were as follows:

	Gel strength	
Pacific whiting surimi lot	Control (no inhibitor)	Inhibitor added
August 1987	82.3	763.8
October 1987	36.0	722.3

The effect of inhibitor addition is obvious. The gel strength is increased 10 times or more. A gel strength of about 650 is needed to make a high quality analog product.

Yellowfin, Bigeye Tuna Tagging Program Underway

A forward-looking group of U.S. east coast sportfishermen, charter boat captains, and sportfishing clubs have joined leading tackle manufacturers, fishing journals, and outdoor writers in an ambitious tag-and-release program for yellowfin and bigeye tuna. This alliance has volunteered over $50,000 worth of prizes, incentives, and awards to anglers who tag and release yellowfin or bigeye tuna taken on rod and reel between 1 March and 1 December 1988.

The tags, which are being distributed through leading saltwater tackle stores that serve tuna fishermen, have been provided through the NMFS Cooperative Game Fish Tagging Program, with the costs underwritten by the tackle manufacturers. Named "Tag A Tuna For Tomorrow," this is an excellent example of government, industry, and the angling public cooperating to promote conservation of an important fishery resource.

Midwest Sends Less Nitrogen to Northeast Than Earlier Believed

The Midwest produces much less of the acidic nitrogen falling on the northeastern United States and Canada than is commonly believed, a computer simulation conducted by the Commerce Department's National Oceanic and Atmospheric Administration (NOAA) shows. More than half of the estimated 1.4 million tons of the material deposited annually in the Northeast comes from sources within the region, the simulation of the transport and deposition of acidic nitrogen concluded. It was conducted in two parts by Hiram Levy II and Walter J. Moxim of NOAA's Geophysical Fluid Dynamics Laboratory in Princeton, N.J.

The first portion of the study showed that 25-30 percent of known nitrogen emissions from auto exhausts and smokestacks in the United States are deposited on North America in rain and snow, as "acid rain," and between 25 and 50 percent in dry fall-out. Government monitoring networks support this finding, indicating that approximately half of the total acidic nitrogen falling on the United States and Canada comes from dry deposits.

In a second series of simulations, Levy and Moxim eliminated from the computer model all emissions of nitrogen oxides from sources outside of the northeastern U.S. and eastern Canada. They then compared the resulting wet and dry deposits in the Northeast with the earlier model. This revealed that about two-thirds of the nitrogen oxides deposited in the Northeast in precipitation came from outside the region, while 80 percent of the nitrogen oxides deposited through dry fall-out and about half the total acidic deposits falling on the northeast were emitted from sources within the region.

Based on the model results, the NOAA investigators, in a paper published in *Nature*, concluded that current monitoring in the northeastern United States and Canada exaggerates the role of acid nitrogen transport from the Midwest, Southeast, and the Ohio Valley, and underestimates the importance of local and regional emissions. The project also showed that emissions remaining in the atmosphere, after both wet and dry deposition, are carried off the continent, principally over the North Atlantic. The model indicates that no more than 200,000 tons of acidic nitrogen from North America reach Europe annually—less than 3 percent of the estimated European emissions of nitrogen oxides.

New Data Center Helps Assess Global Climate

The University of Delaware and the National Oceanic and Atmospheric Administration (NOAA) has announced the creation of a new Joint Center for Research in the Management of Oceanographic Data to be headquartered at Lewes, Delaware. "This cooperative endeavor will help discover the answers to global climate change and related regional oceanographic problems, such as sea level rise, along the east coast," according to Thomas N. Pyke, Jr., NOAA Assistant Administrator for Satellite and Information Services.

The new center has been established at the University's College of Marine Studies at Lewes as a clearinghouse for oceanographic data. It will manage the enormous amounts of oceanographic data available for U.S. east coast areas. The center, dedicated 5 May, will process data generated from NOAA's environmental satellites, which keep a watchful eye on many of the oceans characteristics, including surface temperature and the currents that transport pollutants along the coast.

Recent Trends in World Fish Harvests

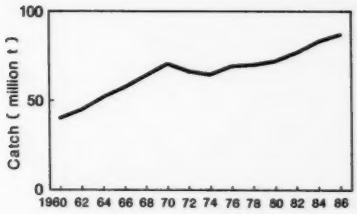


Figure 1.—World fisheries catch, 1960-86.

The world catch of fish, shellfish, and other aquatic organisms reached an all-time record of nearly 90 million metric tons (t) in 1986, according to a preliminary estimate prepared by the Food and Agriculture Organization (FAO) of the United Nations (UN). The estimated 1986 catch was a 5 percent increase over the previous record catch of 85.5 million t set in 1986.[1,2] Despite warnings from environmentalists concerned with rising levels of pollution, fishermen, are continuing to report increasing fishery catches. Since 1980, the world fisheries catch has increased an impressive 25 percent. Developing countries are responsible for most of the increased catch.

Preliminary data suggest that efforts by developing countries in the southern hemisphere to expand their fishing industries will result in continued increases through the year 2000, although this could be affected by a wide variety of economic and climatic factors. The 1986 increase was primarily due to the expanded Asian and, to a lesser extent, Latin American catches. Nearly 40 percent of the total world catch is taken by Asian countries, including Japan, which dominate the world fishing industry. The most rapidly growing catch, however, is in Latin America, where fishery catches have increased by 60 percent since 1980.

Catch Increases

The world fisheries catch has grown steadily since 1980. Annual increases have ranged from a high of 7.9 percent in 1984 to a low of 0.6 percent in 1983 (Table 1). The small 1983 increase was primarily caused by the effects of both the 1982-83 El Niño event in the Eastern Pacific and sharp price increases for fuel. Some observers suggested that the world fisheries catch was leveling off at about 70 million tons in the early 1970's (Fig. 1). The collapse of the Peruvian anchovy fishery in 1971-72 did cause overall world catches to decline during the early 1970's. The predictions, however, that the world catch had reached its maximum potential of conventional species proved erroneous. The expected leveling off did not materialize, and the world catch has expanded continuously since 1977.

The average annual increase during the 1980's was 3.3 percent. The catch since the 1982-83 El Niño has been well above that average level, suggesting that the expansion of the world catch has not yet begun to level off. The increases since 1982 have come mostly from developing countries, and have been achieved even though many countries, especially in Latin America, have had to scale back government-financed fishery development programs as a result of the world debt crisis. Many developing countries have benefited from commercial joint venture arrangements with distant-water fishing companies which in many cases have limited opportunities in their local fisheries and, as a result, have maintained their involvement in overseas fisheries.

Table 1.—Annual world fish catch increases, 1980-86.

Year	Catch (million metric tons)	Percent increase
1980	72.1	1.4
1981	74.9	3.9
1982	76.8	2.5
1983	77.3	0.6
1984	83.4	7.9
1985	85.5	2.5
1986	89.6	4.8
Average		3.4

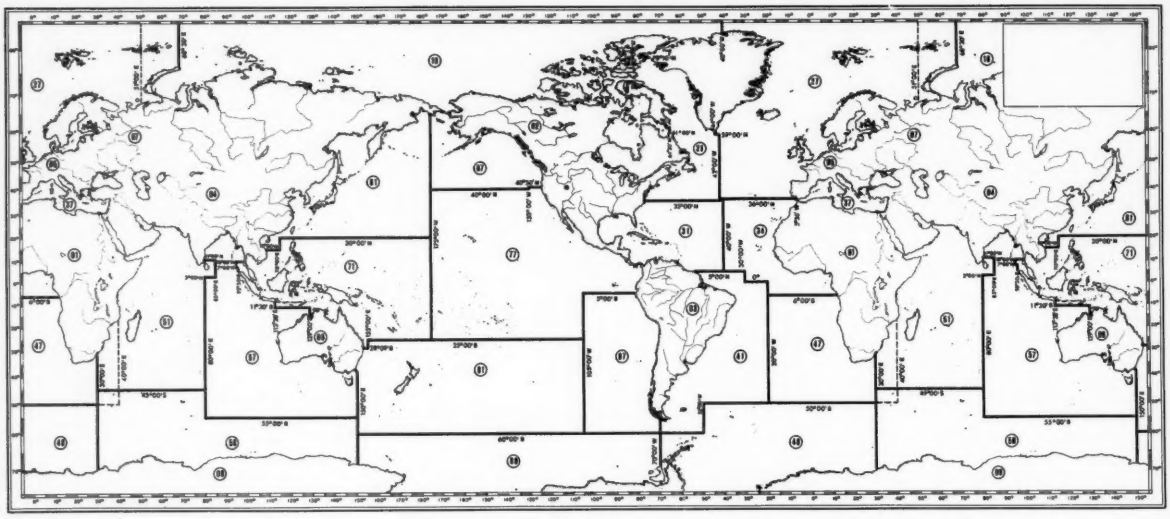
Source: FAO "Yearbook of Fishery statistics."

The NMFS Branch of Foreign Fisheries Analysis has prepared this article based on the quantity of fish and shellfish harvested. Some of the conclusions based on catch trends would be radically different if the value of the catch was calculated. The Branch, however, has decided to deal only with the quantities involved.

This decision is based on several factors. First, the collection and assessment of value data is a much more difficult undertaking, and would require a research effort that cannot at this time be justified. Second, value data includes many nonfishery components such as prices, interest rates, and exchange rates. As a result, such a study would often show fluctuations because of a number of economic factors other than developments in the fishing industry.

[1]This report was prepared as a combined effort of the NMFS Branch of Foreign Fisheries Analysis. Dennis Weidner coordinated the project and was responsible for the world trend and Latin American sections. Other contributors included: Milan Kravanja (Soviet and Eastern European sections), Paul Niemeier (Asian, Oceanian, Japanese, and Chinese sections), William Folsom and Michelle Miller (Western Euopean section), Melissa Zajk (Canadian section), and Steve Wilkshire (African section). It is based on preliminary FAO data available in mid 1987. More recent FAO estimates suggest that the 1986 catch may have hit nearly 91.5 million tons.

[2]For the purpose of this study, the Branch had adopted the widely accepted FAO statistical conventions. Catch data is attributed to the flag of the fishing vessels harvesting the fish and not by the national coastal zone in which it was harvested. Thus, Soviet catches off the coast of Angola are considered Soviet and not Angolan catches. The primary source used for these statistics is the FAO, which in turn relies on each individual country to supply national data. The year 1980 was selected as the base year to focus this report on recent catch developments and to limit the amount of statistical data assessed. As appropriate, the authors have referred back beyond 1980 to explain important longer-term trends.



Major FAO fishing areas.

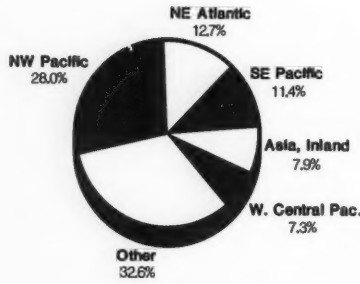


Figure 2.—World fisheries catch by fishing area, 1985.

Table 2.—World fisheries catch, by principal fishing areas, 1985-86.

Region	FAO fishing area	Catch (10^6 t) 1985	1986	1986 Percentage
Northwest Pacific	61	23.8	24.1	27
Northeast Atlantic	27	10.9	10.8	12
Southeast Pacific	87	9.7	11.9	13
Asia, Inland	04	7.1	7.1	8
W. Cent. Pacific	71	6.2	6.5	7
Others		27.7	29.2	33
Total		84.9[1]	89.6	100

[1]This world 1985 catch figure has been updated by FAO to 85.5 million t (Table 1). The updated figure, however, was not used here as the revised breakdown by FAO area was not yet available.

Table 3.—World fisheries catch by major species, 1985-86.

Species	Catch (10^6 t) 1985	1986	1986 Percentage
Alaska pollock	6.1	6.6	7
Peruvian anchovy	1.0	5.1	6
Japanese sardine	4.7	4.8[1]	5
South American sardine	5.8	4.3	5
Capelin	2.3	2.2	2
Atlantic cod	1.9	1.9	2
Chilean jack mackerel	2.1	1.8	2
Chub mackerel	1.8	1.8	2
Atlantic herring	1.4	1.4	2
Other	57.8	57.0	
Totals	84.9[2]	89.6	

[1]Estimated
[2]This catch figure, published in the FAO "Yearbook of Fisheries Statistics," 1985, has been updated by the FAO to 85.5 million t (Table 1). The updated figure, however, was not used here as the revised breakdown by FAO species group was not yet available.

For these and other reasons the authors have decided to focus this discussion primarily on catch trends. Readers should, however, be aware of the limitations of the data and conclusions presented in this report.

Fishing Areas

The world fisheries catch comes from three main geographic areas (Fig. 2). The two most important areas are located in the northern hemisphere: the Northwest Pacific, FAO area 61, and the North Atlantic, FAO area 27 (see map). Fishermen took about 34.6 million t of fish and shellfish from these two areas during 1985, over 40 percent of the world total and over 45 percent of total marine catch (Table 2)[3]. Both areas have large continental shelves supporting important fishery stocks, but their domination of world fisheries is also due to the fact that most of the major developed fishing countries (Japan, the U.S.S.R., China, the United States, South Korea (ROK), Norway, Denmark, Iceland, and Canada) are located in the two regions. The third major fishing area is the Southeast Pacific (FAO area 87), where coastal upwelling supports the massive fisheries for small pelagics off of Chile and Peru.

[3]The 1986 catch by area was not available when this article was written, but the basic pattern is unlikely to change significantly. The FAO data on which this article is based is catch data recorded by the flag of the vessel which caught it and can differ substantially from the area where it is eventually landed.

Species of Fish

Only about eight species are caught in quantities exceeding 1.0 million tons annually (Table 3). The world's single largest fishery in terms of quantity is Alaska pollock, *Theragra chalcogram-*

Table 4.—World catch by major FAO species group, 1980-86.

Name	FAO species group no.	Catch (10^6 t)						
		1980	1981	1982	1983	1984	1985	1986[1]
Small pelagics	35	15.5	17.0	17.9	17.6	19.7	21.2	
Cods	32	10.8	10.7	11.0	11.2	12.3	12.4	
Jacks/mullets	34	7.3	8.0	7.8	8.0	8.5	8.0	
Misc. freshwater[2]	13	5.2	5.5	5.7	6.2	6.5	7.2	
Redfishes	33	5.4	5.3	5.4	5.0	5.5	5.3	
Mackerel/snoeks	37	4.6	4.0	3.8	3.7	4.3	3.7	
Tunas	36	2.6	2.7	2.8	2.9	3.1	3.2	
Shrimp	45	1.7	1.6	1.7	1.8	1.8	1.9	
Others, combined		19.0	20.0	20.7	20.9	21.4	22.0	
Total[3]		72.1	74.8	76.8	77.3	83.1[4]	84.9[4]	89.6

[1]Species group data not available.
[2]Does not include other freshwater species groups: Carps (group 11), tilapias (12), and sturgeons (21); the combined total of these three groups in 1985 was 1.3 million t.
[3]Totals may not agree due to rounding.
[4]These world 1984 and 1986 catch totals have been updated to 83.4 million t and 85.5 million t, respectively in Table 6, but are not to be used here as the revised breakdown by FAO species group was not available.

Table 5.—World catch increase of major species groups, 1980-85.

Name	FAO species group	Changes 1980-85	
		Amt. (10^6 t)	Percent
Small pelagics	35	5.7	45
Other (unspecified)		3.0	23
Misc. freshwater	13	2.0	16
Cods	32	1.6	12
Jacks/mullets	34	0.7	5
Tunas	36	0.6	5
Shrimps	45	0.2	2
Redfishes	33	−0.1	−1
Mackerels/snoeks	37	−0.9	−7
Total		12.8	18

ma, and reported catches of that species totaled 6.6 million t in 1986. Most of the fisheries for these important species were little changed in 1986. The only major shift was a massive increase in the Peruvian anchovy fishery. Fishermen from Peru and Chile reported a 1986 catch of 5.1 million t, more than a 400 percent increase from the 1.0 million t reported in 1985.

North Pacific pollock fishermen reported the only other significant increase (+0.5 million t). Peruvian and Chilean fishermen reported the largest declines, in the sardine (−1.5 million t) and jack mackerel (−0.3 million t) fisheries.

The world catch is composed primarily of three species groups: Small pelagics, cods, and jacks, which had a combined catch of over 40 percent of the world catch for all species in 1985 (Table 4). The single most important group is small pelagics (anchovies, herrings, sardines, etc.) and catches of that group totaled 21.2 million t, nearly 25 percent of the world total for all species. About half of the increase in the world catch since 1980 has resulted from increased catches of these small pelagic species (Table 5). Other important increases were reported for various other marine fish and shellfish (up 23 percent), miscellaneous freshwater fish (up 16 percent), and cods (up 13 percent).

The massive increases of small pelagics is significant because the expansion of these fisheries means that the increase of the world catch has not resulted in a corresponding increase in the production of edible commodities. A large portion of the small pelagic catch is reduced to fishmeal, used principally for animal feed[4]. Catches of all major species groups used for edible products have been increasing at very low rates or have actually declined (Table 5)[5]. It should also be noted that small pelagic fisheries are subject to sharp annual fluctuations. Overall fluctuations may be less likely in the 1980's as fishing effort is now divided over a number of different stocks. In the early 1970's, small pelagic fisheries were centered on a single species, the Peruvian anchovy. The catch of Peruvian anchovy in 1970 was 13.1 million t, 60 percent of the world small pelagic catch of 21.4 million t. Obviously, significant changes in that stock had a major impact on the total world catch of small pelagic species. Catches are now more widely diversified over several different stocks in different areas. The most important small pelagic taken in 1985 was South American sardine, but its catch of 5.8 million t was only 27 percent of the 21.2 million t of small pelagics taken worldwide. Various small pelagic species react differently to climatic changes. Thus, while Peruvian anchovy declined after the 1972 El Niño, stocks of sardine and mackerel increased. Thus, when stocks are more diversified, fluctuations of one species may, to some extent, be offset by countervailing fluctuations of other species.

Developed and Developing Countries

A major shift occurred in the harvest of world fishery resources during the 1980's. Developing countries replaced developed countries as the principal world harvesters of fishery stocks (Fig. 3)[6]. The developed countries have traditionally dominated world fisheries. In 1980, developed countries reported a catch of 38.4 million t, or 53 percent of the world total (Table 6). Since 1980, the developed countries have reported only a modest catch increase of 12 percent to 42.9 million t in 1986. The combined effect of overfishing in the coastal waters of developed countries (primarily in the North Atlantic and North Pacific) and the increasing restrictions, placed by developing countries on distant-water fishermen have limited the recent catch

[4]Eventually, of course, most of the animals are slaughtered for human consumption. so even fishmeal production does increase food production. The increase of poultry and livestock produced, however, will only be a fraction of the amount of fish used to produce the fishmeal.
[5]Cods are the only major species group used primarily for direct human consumption that has increased more than 5 percent since 1980.
[6]The FAO's definition of developed and developing countries is used. The FAO breakdown is detailed in Table A-5 of the 1985 "Yearbook of Fishery Statistics." Data submitted by some developing countries should be considered rough estimates as they are often computed without an extensive data collection system.

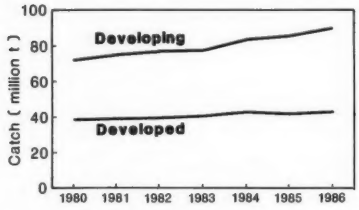


Figure 3.—Fisheries catch by type of country, 1980-86.

Table 6.—World fisheries catch, by type of economy[1], 1980-86.

Year	Catch (10^6 t)		
	Developed	Underdeveloped	Total
1980	38.4	33.8	72.1
1981	39.0	35.8	74.9
1982	39.4	37.4	76.8
1983	40.4	36.9	77.3
1984	42.7	40.7	83.4
1985	41.9	43.6	85.5
1986	42.9	46.7	89.6

[1]Developed and developing countries are identified in Table A5 of the 1985 edition of the FAO "Yearbook of Fishery Statistics."

Table 7.—Catch and industry data for major fishing countries, 1986.

Country	Catch		Type of industry
	Amt. (10^6 t)	Share[1]	
Japan	11.9	13%	Private
U.S.S.R.	11.1	12	State owned
China	7.3	8	State owned
Chile	5.6	6	Private
Peru	5.3	6	Mixed
United States	4.9	5	Private
Korea (ROK)	3.1	3	Private
India	2.8	3	Private
Indonesia	2.5	3	Private
Thailand	2.1	2	Private
Norway	1.9	2	Private
Philippines	1.9	2	Private
Denmark	1.8	2	Private
Korea (DPRK)	1.7	2	State owned
Iceland	1.6	2	Private
Canada	1.5	2	Private
Other	22.6	25	
Total	89.6		

[1]Percentage of the total world catch.

Table 8.—World fisheries catch of major fishing countries by economic organization, 1986.

Type of industry	Catch[1] (10^6 t)	Percentage
Private	41.6	62
State owned	20.1	30
Mixed	5.3	8
Total	67.0	100

[1]Only the catch of the major fishing countries detailed in Table 9 are computed in this table. These countries represent about 75 percent of the world catch.

increases of the developed countries. Developing countries, on the other hand, achieved a catch of 46.7 million t by 1986, or 52 percent of the world total. The 1986 catch of the developing countries was nearly 40 percent over 1980 levels. (From 1967 to 1971 the total catch of the developing countries increased sharply because of massive catches of Peruvian anchovy.) The steadily expanding catch of Chile and Peru and the rapidly expanding fisheries of several developing Asian countries account for most of the increase. Many developing countries, however, have not participated in this expansion. Few African countries, for example, have increased their catch since 1980, even though fish is a critical component of the diet in many of them.

Type of Industry

The economic organization of the major fishing countries varies sharply (Table 7). The two leading countries are classic examples of private (Japan) and state-owned (Soviet Union) fishing industries. Japan's fishing industry is the most modern in the world, efficiently providing food and jobs to Japan as well as tax revenues to the Government. In recent years, however, the Government has increasingly funded programs to assist Japanese fishermen adjusting to the ever tightening restrictions on distant-water fishing. The Soviet fishing industry, only slightly less productive than the Japanese, is markedly less efficient.

A rough estimate of the relative efficiencies of the two countries can be obtained by comparing their fleets. The Soviets, in 1986, reported a fleet of 2,800 fishing vessels totaling 3.7 million gross tons. The Japanese, on the other hand, exceeded the Soviet catch with a much smaller fleet, about 2,700 vessels totaling only 0.9 million gross tons. Precise data are not available on the profitability of the Soviet fishing industry, but it is widely believed that the real cost of the fish produced by the Soviets could not be justified by market-based prices. (An accurate comparison of the two countries would require a much more detailed assessment including differences in fleet deployment, target species, operating costs, markets served, and many other factors.)

The predominant pattern for fishing industries is private companies. Of the 16 leading countries in 1986, 11 with over 60 percent of the world catch had basically privately owned industries (Tables 7, 8). Three countries with 30 percent of the catch had state-owned industries. Only one major fishing country (Peru) had a mixed fisheries economy with ownership by both private and state-owned companies.

Pollution

Environmentalists warn that increasing levels of pollution may adversely affect fisheries production. The United Nations Environmental Program (UNEP) has attempted to address the oceanic pollution problem through its Regional Seas Program, but most observers continue to report rising levels of pollution in the world's oceans. Some small fisheries have been impaired, especially freshwater fisheries and estuarine-dependent coastal fisheries. Marine debris, especially "persistent" plastic materials, is causing increasing mortalities of several marine mammals, sea turtles, birds, and other marine life. Environmentalists, however, have not yet compiled conclusive evidence to substantiate their concerns regarding damage to the major marine fish stocks such as Alaska pollock, capelin, Japanese or Chilean sardine (FAO refers to some sardines as pilchards), or others as a result of marine pollution.

The world fisheries catch has expanded during the 1970's and 1980's despite increasing levels of pollution. Increases have been reported even in heavily polluted areas. For example, the Mediterranean is probably the FAO area most heavily polluted, but catches there

increased from 1.6 million t in 1980 to 1.9 million t in 1985. Some observers warn that pollution is affecting fish stocks, but the impact, if any, has so far been masked by other factors. Fish stock abundance has apparently been affected less profoundly by pollution than the combined effects of increasing fishing effort and climatic variations. The effects of these two variables may be masking the more limited impact of pollution on important marine stocks. Considerable caution should be used in using global catch statistics to assess the impact of pollution. Most of the increased fisheries catch since 1980 has come from a small number of small pelagic stocks (Table 5). A thorough examination of the pollution problem would have to assess possible impact on the much larger number of traditional species for which catches have increased only marginally despite substantially increased fishing effort (Table 5).

While scientists have yet to prove that substantial declines in catches of major marine species have been caused by pollution, there is mounting evidence that some marine stocks are being affected. While the catch of cods as a group has increased since 1980 (Table 4), scientists are increasingly concerned over Atlantic cod (Table 3). Atlantic cod catches have declined from 2.2 million t in 1980 to only 1.9 million t in 1985.

Pollution does result in the contamination of some fishery resources. However, concerns over product safety are for the most part limited to freshwater fish and marine or near-coastal species subject to incidental exposure to industrial and agricultural chemicals such as PCB's and pesticides. It should be noted also that many of the species likely to be affected are caught by recreational fishermen and may not be of major commercial importance. Individual countries vary in the extent to which they are alert to these problems. Some countries provide effective consumer protection through the issuance of public health advisories and, if judged necessary, by closure of selected fisheries. Action levels for specific contaminants are set with the added insurance of large safety factors, usually several orders of magnitude.

Table 9.—World fisheries catch by regions, 1980-86.

Region	Catch (10^6 t)							Percent increase
	1980	1981	1982	1983	1984	1985	1986	1980-86
Asia	30.1	31.5	32.3	34.0	36.0	36.7	38.2	27
Latin America	9.6	10.3	11.4	9.2	12.0	13.6	15.6	62
Europe	12.5	12.5	12.2	12.6	12.9	12.6	12.3	−2
U.S.S.R.	9.5	9.6	10.0	9.8	10.6	10.5	11.1	17
North America	5.1	5.3	5.5	5.7	6.2	6.3	6.6	29
Africa	4.1	4.3	4.1	4.4	4.1	4.1	4.2	2
Middle East	0.8	0.9	0.9	1.0	1.0	1.0	1.0	25
Oceania	0.5	0.5	0.5	0.6	0.6	0.6	0.6	20
Total[1]	72.1	74.9	76.8	77.3	83.4	85.5	89.6	24

[1]Totals may not agree because of rounding.

Geographic Regions

The world fisheries catch is dominated by Asian[7] fisheries (Table 9). Asian fishermen caught 38.2 million t of fish and shellfish in 1986, nearly 40 percent of the total world catch (Fig. 4). The most rapidly growing area, however, is Latin America, and catches in that region, especially in the Pacific, have grown over 60 percent since 1980 (Table 9a), primarily because of steadily increasing catches of small pelagic species by Chile, Peru, and Ecuador. Major developments in each of the important world fishing regions are given below.

Table 9a.—World fisheries catch increase, 1980-86.

Region	Percent increase (1980-86)	Region	Percent increase (1980-86)
Latin America	62	U.S.S.R.	17
North America	29	Africa	2
Asia	27	Europe	−2
Middle East	25		
Oceania	20	World average	24

Asia

Asian countries dominate the world fishing industry, accounting for over 40 percent of the total world catch in 1986 (Table 9). The Asian catch increased by 4 percent over the 1985 catch and has increased by over 25 percent since 1980. One of the most significant developments in Asia during the 1980's has been the steady increase of important aquaculture industries. At first, farmers in developing countries targeted low-valued species for local consumption, but many others increased the production of high-valued species for luxury markets. The most spectacular development has been the massive expansion of the pond-shrimp industry. The Branch estimates that Asian shrimp farmers harvested about 260,000 t of shrimp in 1986, nearly a 400 percent increase from the 55,000 t harvested as recently as 1982. The leading shrimp farming countries

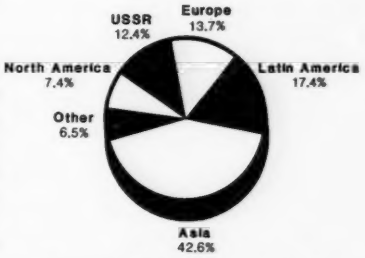


Figure 4.—World fisheries catch by region, 1986; total for 1986 was 89.6 million t.

[7]The Branch has chosen to assess fishery catch developments by continent because of interest in national developments. Such an analysis, however, is not a good way of organizing biological trends, especially for regions such as Asia and Latin America which have coasts spanning two or more oceans. An assessment by ocean region could provide useful insights, but for the purposes of this study this subject has been addressed only briefly. Note also that the following data is calculated on the basis of the flag of the fishing vessel, and not where the fish was caught. In some regions, especially Africa, the regional catch total would be much higher if the catch of the distant-water countries operating off Africa was added to the regional total.

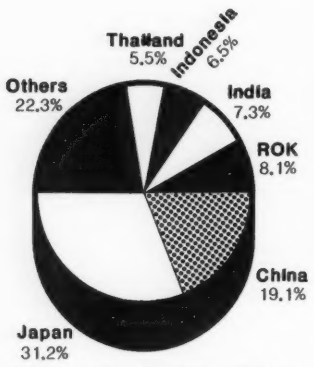


Figure 5.—Asian fisheries catch by country, 1986; total for 1986 was 38.2 million t.

are China, Taiwan, Indonesia, the Philippines, and India.

Japan is the single most important Asian fishing country, but the region's catch is divided among seven other major countries: China, South Korea (ROK), India, Indonesia, Thailand, the Philippines, and North Korea (DPRK) (Fig. 5). Eight of the world's 16 leading fishing countries are Asian (Table 7). These eight countries accounted for 87 percent of the 1986 regional catch. All of these countries, except for Thailand and the Philippines, reported catch increases in 1986. The fishing industry plays a much more important economic role in these countries than is the case for the United States or European countries. In Japan, for example, about half of the animal protein consumed is derived from marine organisms.

Asian countries reported several major developments in 1986. Japan harvested a near record 11.9 million t and reported increased aquaculture production and offshore catches, especially of sardines. China reported steady growth in all sectors of the fishing industry. The 7.9 million t catch increased 7 percent and included impressive increases in marine and freshwater fisheries and aquaculture. Chinese Government officials are projecting a catch of 9 million t by 1990, primarily as the result of increased aquaculture production. The ROK 1986 catch totaled 3.1 million t, an impressive 15 percent increase over 1985 results. Much of the ROK increase was due to the country's expanding U.S. joint venture fishery and entry into the squid fisheries of the North Pacific and Southwest Atlantic. The country's aquaculture industry has also continued to grow steadily.

India's catch of 2.8 million t has changed little since 1984, with most of the marine catch coming from heavily exploited inshore waters. The Indian Government has been trying to promote a deep-sea fishery since 1968, but has had only limited success. Indonesia reported a 1986 catch of 2.5 million t, an increase of 9 percent over the 1985 catch. Indonesia, like India, depends on artisanal fishermen using traditional methods for most of its catch. The 1986 increase was primarily due to the gradual mechanization of the Indonesia fleet, extending its range to more distant coastal fishing grounds. Government officials believe that the country can significantly expand the fisheries catch to as much as 8 million tons.

Thailand and the Philippines both experienced slight declines in 1986. Thai grounds are heavily fished and Thai fishermen are having increasing difficulty maintaining their fisheries off other countries. Filipino fishermen have some of the same problems and may be feeling the effect of using such destructive fishing practices as using dynamite and cyanide. Much of the decline in the Filipino catch is being offset by the steady growth in the country's aquaculture industry.

Latin America

Latin American countries report the world's second most important fisheries catch, representing nearly 20 percent of the world total. Over 80 percent of the Latin American catch is taken in the Pacific. Catches totaled 15.6 million t in 1986, a 15 percent increase over the 13.6 million t taken in 1985. The 15.5 million t total does not include the more than 1.0 million t taken by distant-water countries (primarily the U.S.S.R., Poland, and Japan) off various Latin American countries (primarily Argentina, Chile, and Peru). Latin American catches increased in 1986 to a level approaching the record regional catch levels taken before the collapse of the Peruvian anchovy fishery in 1972.

Two countries, Peru and Chile, dominate Latin American fisheries (Fig. 6). Chile is the leading country with a catch

The Taiwanese Fishing Industry

Taiwan's 1986 fisheries catch totaled a record 1,095,000 t, nearly a 6 percent increase over the 1985 catch of 1,038,000 t. The value of the 1986 catch increased even more (by over 18 percent) to almost $2 billion. The deep-sea fisheries catch, over 45 percent of the total, was nearly 500,000 t. Inshore, coastal, and aquacultural production totaled 276,000 t, 55,000 t, and 266,000 t, respectively.

Taiwan exported 265,000 t of seafood in 1986, valued at $1.2 billion, an increase of 19 percent by quantity and 43 percent by value over 1985 exports. (The large increase in value reflects, in part, the fact that the new Taiwan dollar appreciated by 13 percent against the U.S. dollar in 1986.) Shrimp, eel, and tuna continued to be the three major fishery export commodities, comprising a combined 43 percent by quantity and 76 percent by value of total 1986 fishery exports. Japan was by far the largest purchaser of Taiwan's fishery products, followed by the United States, Australia, Saudi Arabia, Hong Kong, Italy, and the Federal Republic of Germany. The American Institute in Taiwan has prepared a 28-page report on Taiwan's fishing industry in 1986-87 containing a general outline and sections on the fisheries catch, fleet, processing capability, development plans, trade, and international agreements. The report also includes a brief section describing opportunities for U.S. exporters of fishery products and equipment. U.S. companies can obtain a copy of this report for $12.95 plus a $3.00 handling fee (personal check or money order) by ordering report number PB88-209002/GBA from the National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161.

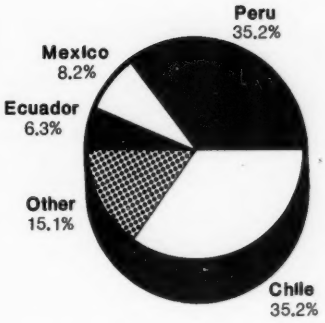


Figure 6.—Latin American fisheries catch by country, 1986; total for 1986 was 15.6 million t.

totaling 5.6 million t in 1986, followed by Peru with a catch of 5.3 million tons. The two countries combined accounted for 70 percent of the regional total. Almost all of the Latin American 1986 increase was the result of increased harvests by these two countries. Over 90 percent of the Chilean and Peruvian catch is sardine, anchovy, jack mackerel, and horse mackerel which is reduced to fishmeal. Peru reported substantially increased anchovy catches in 1986. Anchovy was the mainstay of the Peruvian fishing industry during the 1960's and early 1970's, but had declined to negligible levels in 1985. The Chilean increase was also due to increased anchovy catches, as the sardine and jack mackerel declined. Other important fishing countries in the region include: Mexico (1.3 million t), Ecuador (1.0 million t), Brazil (0.9 million t), and Argentina (0.4 million tons).

A few species dominate the Latin American catch. Latin American countries primarily harvested massive quantities of the reduction species mentioned above. Fishermen also conduct smaller fisheries, but in some cases more valuable ones, for hake, tuna, shrimp, and lobster. A wide variety of other species are caught in smaller quantities.

Several countries reported major fishery developments in 1986. Mexico significantly expanded its tuna industry, and now operates one of the world's most modern tuna fisheries. Ecuador reported record results in its pond shrimp industry which allowed it to become the second most important source of shrimp imported by the United States. Many observers believe that Ecuador may replace Mexico as the major source of U.S. imported shrimp in 1987.

Argentina achieved encouraging results because of a strengthening international market for groundfish, the country's principal fishery, but fishermen reported a declining shrimp catch. Argentine companies complained of increasing competition with the foreign companies operating off the Falklands. The British announced in 1986 that they planned to begin managing fishery resources off the Falklands. Chilean farmers have begun to harvest salmon; while harvests are still small, some observers believe it could develop into an important new fishery. Peru reported a sharp drop in its new scallop fishery, but Panama reported an increase. At the end of 1986, several Eastern Pacific countries began to report a mild El Niño event, but it apparently had little impact on year-end results. The event was centered in waters off Ecuador and northern Peru. Preliminary reports suggested that the 1987 catch of several countries might have been significantly affected.

Europe

European fishermen caught 12.3 million t of fish and shellfish in 1986, making Western Europe the third most important fishing area in the world. European catches, unlike those of many other regions, have remained stable during the past 7 years, ranging from a low of 12.2 million t in 1982 to a high of 12.9 million t in 1984. The major fishing countries are the Scandinavian countries and Spain (Fig. 7).

Eastern Europe

Eastern European countries harvested almost 1.4 million t of fish and shellfish in 1986, or over 35 percent more than in 1970 when the total catch amounted to only 1.0 million tons (Table 10). The most important country is Poland, which harvested 0.6 million t, nearly half of the total for the entire region. The Poles consume about 17 kg per capita of fishery products annually,

Peruvian Fisheries, 1986-87

Peru's 1986 fisheries catch totaled 5.5 million t, a 34 percent increase over the 1985 catch, mostly generated by a 300 percent increase in the anchovy catch. The catch of other major species declined. Fishery exports in 1986 were 780,000 t, an increase of 13 percent, mostly because of increased fish meal production. Fish meal exports accounted for about 8 percent ($200 million) of Peru's total 1986 export earnings. The Peruvian Government, in early 1987, initiated a Fisheries Reactivation Fund aimed at rebuilding the fleet and upgrading the equipment of the artisanal fishermen. The Fund will be financed by a 5 percent tax on the fishmeal exports earnings of the private companies.

The Government plans to increase nontraditional exports, including frozen shrimp and scallops, by making credit available and improving the management of these resources. The Peruvian Government is also promoting domestic consumption of fishery products by creating a state-owned fishing fleet (FLOPESCA) and negotiating joint venture agreements with distantwater-fishing countries. The U.S. Embassy in Lima has prepared an 18-page report reviewing the status of the Peruvian fishing industry in 1986 and 1987. The report covers the 1986 fisheries catch, impact of the fishing industry on the economy, state-owned companies, domestic consumption, modernization of the fleet, fishmeal production, new initiatives (shrimp and scallops), joint ventures (Cuba and the U.S.S.R.), 1987 projections, and implications for U.S. exporters. The report includes statistical tables, with data available up to June 1987. U.S. companies can obtain a copy of the report "Peru: Annual Fisheries Report, 1986-87" for $12.95 and a $3.00 handling fee (total $15.95, personal checks or money orders only) by ordering report PB88-205422/GBA from NTIS, Springfield, VA 22161.

the highest in Eastern Europe. Most of the Polish catch is taken by the country's distant-water fleet which extended its operations in the southern Atlantic. The Poles currently conduct a major fishery for squid and southern blue whiting off the Falklands.

Bulgaria, East Germany (GDR), and Romania also obtain most of their fisheries catch from distant-water operations. Most of the Eastern European catches peaked in 1975 before the extention of 200-mile zones by many coastal countries. The major exception is Romania, whose catch has more than doubled since 1975. Yugoslavia and Albania, unlike the other Eastern European countries with marine coasts, fish primarily in coastal Adriatic waters. Both countries report only small catches. The isolationist tendency of Albania has discouraged the development of a fishing industry. Landlocked Hungary and Czechoslavakia harvest a

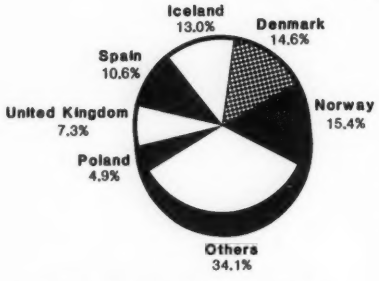


Figure 7.—European fisheries catch by country, 1986; total for 1986 was 12.3 million t.

Table 10.—Eastern European fisheries catch, 1970-86.

Country	Catch (10^6 t)					Population in millions (1986)	Consumption (kg per capita)
	1970	1975	1980	1985	1986		
Poland	469.3	800.7	640.6	683.5	645.2	37.2	17.3
Romania	58.6	136.6	173.6	237.6	271.1	22.7	11.9
E. Germany (GDR)	321.8	376.2	235.3	197.7	208.9	16.7	12.5
Bulgaria	95.6	158.1	126.4	100.2	109.2	9.0	12.1
Yugoslavia	46.2	56.6	58.4	75.0	77.6	23.1	3.4
Hungary	26.0	30.8	33.7	36.9	36.1	10.6	3.4
Czechoslovakia	13.4	16.9	16.0	19.8	20.7	15.5	1.3
Albania	4.0[1]	4.0[1]	4.0[1]	4.0[1]	4.0[1]	3.1	1.3
Total	1,034.9	1,579.9	1,288.0	1,354.7	1,372.8	137.9	10.0

[1]Estimated

FRG SEAFOOD MARKET, 1986

The demand for fishery products in the Federal Republic of Germany (FRG) has increased from $1.0 billion in 1985 to $1.5 billion in 1986, and could exceed $2.0 billion by by 1990. German per capita consumption of fishery products rose from 11.8 kg in 1985 to 13.2 kg in 1986 because of greater consumption of frozen fish by private households, institutions, and "fast-food" restaurants. In 1986, frozen fish outsold fresh fish for the first time. Purchases of frozen fish products, particularly frozen fish sticks and fish fillets, are expected to continue and to contribute to growth in the German fish consumption.

Landings by the FRG fleet during 1986 decreased to 201,000 t from 229,000 t in 1985. Fishery landings are expected to decline to 185,000 t by 1990 due to the reduction of the fleet, which now consists of 7 fresh fish trawlers and 5 stern factory trawlers. As a result, imports will continue to supply most of the rapidly increasing German demand for fishery products. Fish and seafood imports in 1987 are expected to reach $1.1 billion compared with $0.6 billion in 1985. Imports of fishery products from the United States amounted to only $8 million in 1986. On the other hand, the United States imported $75 million worth of fishery products from the FRG in 1986. The U.S. Consulate General in Hamburg has prepared a 9-page report reviewing the market for fishery products in the FRG. The report includes statistical tables of landings, trade, and consumption, and lists of trade fairs, trade associations, and trade publications. U.S. companies can obtain a copy of "The Federal Republic of Germany's Seafood Market, 1986" for $9.95 and a $3.00 handling fee (total of $12.95, personal checks or money orders only) by ordering report PB88-114582/GBA from NTIS, Springfield, VA 22161.

Fish Consumption Grows in France

French consumption of fresh, frozen, and otherwise processed fish and shellfish during 1984 increased to some 680,000 t, or 11 kg per household. This 4 percent increase continues an upward trend observed since 1979. Sales of frozen seafood increased by 10 percent, while sales of smoked, dried, or salted seafood rose by 4 percent. Of the total fishery market, whole fresh fish represent over half of sales. Particularly important species are whiting, pollock, cod, hake, and sardines. Traditional methods of marketing fish in France (fishmongers, open markets) have given way to dominance by large supermarkets. During 1984, supermarkets handled more than one-fourth of all the whole fresh fish sold in France and 37 percent of the fresh fillets.

Despite steadily decreasing inflation in France since 1982, the average retail price for fish has increased more than 18 percent from 1984 to 1985, due to higher transportation and storage costs. The U.S. Embassy in Paris has prepared a 9-page report reviewing the French market for fishery products during 1984, including data on sales, pricing, and distribution of seafood. U.S. companies can obtain a copy of "The French Fishing Industry, 1984" for $9.95 and a $3.00 handling fee (total $12.95, personal checks or money orders only) by ordering report PB88-114640/GBA from NTIS, Springfield, VA 22161.

small catch from inland waters and growing fish culture operations.

Western Europe

Increases in catches have taken place mostly in Iceland, the Netherlands, and Ireland, while decreasing in Norway, the Federal Republic of Germany, Spain, and Portugal. The decline in the Western European catch was caused by overfishing, stricter enforcement of regulations in the heavily fished European waters, and the loss of traditional distant-water fishing grounds. Of particular concern to many European nations has been the decline in popular species such as Atlantic cod, saithe, and haddock catches in the North Sea. The discovery of rich squid fishing grounds off the Falkland Islands has helped maintain catch levels for the Spanish fleet, which has been particularly hard-hit in recent years. The European Community (EC) is actively seeking new fishery agreements with developing nations around the world which will permit EC vessels to continue fishing.

U.S.S.R.

The U.S.S.R. is the world's second most important fishing country. The Soviets reported a 1986 catch of 11.1 million t, a 6 percent increase from the 10.5 million t reported in 1985. (This does not include the fish taken by U.S. fishermen and then sold over-the-side to the Soviets. These joint venture purchases provided the Soviets an additional 223,000 t in 1986.) The Soviet Union has invested massively in developing its high-seas fisheries for both economic and strategic reasons.

Table 11.—The U.S.S.R. fisheries catch, 1976-86.

Year	Catch (1,000 t)	Change[1] Tonnage	Change[1] Percentage
1976	10,121	157	1.6
1977	9,351	-770	-7.6
1978	9,000	-351	-3.8
1979	9,049	49	0.5
1980	9,476	427	4.7
1981	9,546	70	0.7
1982	9,957	411	4.3
1983	9,757	411	-0.2
1984	10,593	836	8.6
1985	10,523	70	-0.1
1986	11,100	567	5.4
10-Year change		+979	+9.7

[1]Change from previous years, in 1,000 t and percentage.

From a relatively small catch of about 1 million t in the 1920's, Soviet fishermen expanded their operations into all of the world's oceans and harvested over 11 million t of fishery products in 1986 (Table 11). The Soviets first reached the 10 million t harvest in 1975, before most major coastal countries extended their fisheries jurisdiction to 200 miles (Fig. 8). In the years that followed, many coastal fishing countries severely limited (the United States and Canada) or prohibited (the EC) Soviet fishing operations. Soviet fishermen developed a reputation for ruthless exploitation of fishery resources and many coastal countries extended their coastal jurisdiction to 200 miles to protect their coastal resources from Soviet and other distant-water fishermen. As a result, the Soviet fisheries catch decreased by over 11 percent during 1977-78 and did not reach the 10 million t level again until 1984 (Table 11).

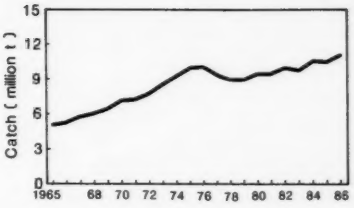


Figure 8.—Soviet Union fisheries catch 1965-86.

The Soviets were much slower than the Japanese in countering the limiting effects of extended jurisdiction by concluding joint-venture and fisheries-assistance agreements. Their state-owned company, Sovrybflot, though ad-

Norwegian Salmon Exports

Norwegian fish farmers seem set to break all previous records in farmed salmon exports. Total exports for 1988 could well outstrip last year's figures by as much as US$166 million, according to the Norwegian Information Service, Norinform. Production and exports have soared so far this year, and the final export figure for 1988 will be between US$500 and 590 million.

First quarter sales figures showed a first-hand turnover of US$107 million, compared with US$67 million last year. Production in the same quarter was 15,625 tons, against 11,720 million tons in the same period last year. Information officer Odd Ustad in the central sales organisation for fish farmers says that favorable temperatures have stimulated growth, and that the major disease problems appear to be under control. Demand in the markets is high, with France retaining its first place as recipient of Norway's farm salmon.

Norwegians Target Antarctic's Krill

Three Norwegian firms are planning to harvest the bountiful supplies of krill in the Antarctic to sell to the United States, Great Britain, and Japan, according to the Norwegian Information Service. Millions of dollars will be invested in projects which are scheduled to be under way as early as autumn 1988, when giant factory ships will move south to start the fishing.

The high-protein, shrimplike krill can, according to Norwegian sources, be eaten plain, ground into forcemeat, or served as krill "sticks." It can also be used as a coloring matter for other foods such as trout, salmon, and sausages. Furthermore, krill oil, rich in polyunsaturates, could be useful to the pharmaceutical industry, as a possible rival to cod liver oil, Norinform reports. About 200-250 tons of krill per day is believed a realistic target and the Norwegians believe that there will be no danger of depleting the enormous resources for "many years." However, they also warn that if the supplies of krill, the main food of seabirds and whales, were to be threatened, the entire ecological balance of the oceans could be disrupted.

ministered by capable and experienced managers, was saddled with numerous regulations and bureaucratic inefficiencies that are so prevalent in Soviet operations with foreign companies. This may change now that former Minister of Fisheries (V. M. Kamentsev) was appointed by General Secretary Gorbachev to become not only a member of the Soviet Council of Ministers, but also Chairman of the Federal Foreign Economic Commission. In this latter capacity, Kamentsev will oversee and determine the policy of joint ventures with foreign countries and companies.

One important trend in Soviet fisheries since 1980 has been an increasing reliance on coastal waters. Soviet catches in coastal waters (FAO areas 18, 27, and 61) totaled 6.7 million t in 1985, a 30 percent increase over the 5.1 million t reported in 1980. All of the increase has occurred along the Soviet Pacific coast as catches along the heavily fished Atlantic and Barents Sea coast have declined and catches along its northern Arctic coast are negligible. The Soviets have also shifted their fishing industry from the Atlantic to the Pacific (Fig. 9). Soviet fishery harvests (by FAO fishing area) have changed greatly during the last decade. In 1975, the Soviet Atlantic catch (5.0 million t) was more than twice the Pacific catch (2.2 million t). By 1985, this relationship had totally changed and the Soviet Pacific catch, at 6.2 million t was 50 percent larger than the Atlantic catch of 4.1 million t (Table 12).

The Soviet Atlantic catch has decreased in all regions, except the Southeast Atlantic (FAO area 47) off Namibia and Angola where the Soviets operate under the International Commission for Southeast Atlantic Fisheries (ICSEAF) regulations. In the Northwest Atlantic (FAO area 21), the Soviet catch has declined over 1.0 million t between 1975 and 1985 as the United States and Canada extended their fisheries jurisdiction to 200 miles and severely reduced distant-water fishing. In the Northeast Atlantic (FAO area 27) the Soviet catch has declined another 1.2 million t because of declining stocks and the fishing regulations enforced by the European Community (EC) and several

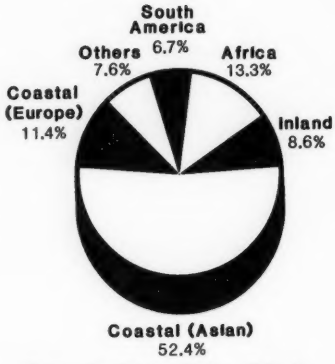


Figure 9.—Soviet Union fisheries catch by area, 1985; total for 1985 was 10.5 million t.

coastal countries. The Soviet fishery in that area is now limited to the Barents Sea and international waters between Iceland and the Svalbard Islands. Worried by a tottering resource base and the Soviet penchant for relentless overfishing, the EC has permitted no Soviet fishing since extending their coastal zone to 200 miles in 1977.

In the Western Central Atlantic (FAO area 31), the Soviet catch has always been small and proved such an economic burden that they abandoned it in 1977. The Soviets, however, retain a vessel repair and transshipment operation in Havana, Cuba. In the Eastern Central Atlantic (FAO area 34), the Soviets conduct one of their most important distant-water operations aided by bilateral agreements with several African countries and by fishing in the coastal waters of several countries with which they have no such agreements. Few African countries have effective surveillance and enforcement capabilities.

In the Pacific, the largest Soviet fishery has historically been conducted off their own coasts and the adjacent waters of the Bering Sea and Northwest Pacific (FAO area 61). The catch in this area has doubled during the past 10 years, but it remains greatly, and possibly dangerously, dependent on a single species, the Alaska pollock. The Soviet pollock catch, amounting to 3.3 million t in 1985, or 30 percent of the entire Soviet catch in that year. It is landed in Siberian ports and then primarily shipped by rail to population centers in the western part of the country where it is marketed to Ryba and other retail stores. Few other Pacific grounds are important to Soviet fishermen, except for the Southeast Pacific where the Soviets fish outside the 200-mile zones of Peru and Chile. Efforts to gain access to coastal waters failed when the Allende Government fell in Chile during 1973 and when the Peruvians refused to renew joint venture agreements in 1985.

In the Antarctic, the Soviets have attempted to initiate a krill fishery, and catches reached a record 0.5 million t in 1982. The operation, however, proved difficult and costly, and Soviets had difficulty marketing krill products. Catches declined sharply in 1983 and in 1985 totaled only 0.2 million tons. The Soviets announced in late 1987 some technical innovations which they believe

Table 12.—U.S.S.R. fisheries catch for selected years by major fishing areas, 1970-85.

Fishing grounds	FAO area	Catch (1,000 t) 1970	1975	1980	1985
Inland waters	7	855	944	753	906
Black Sea	37	303	350	391	345
Atlantic					
Northwest	21	812	1,167	108	133
Northeast	27	1,566	2,406	1,984	1,239
W. Central	31		69		
E. Central	34	613	1,166	942	708
Southwest	41	421	9	28	71
Southeast	47	423	421	825	698
Subtotal		4,993	6,532	5,031	4,100
Indian Ocean					
Western	51			37	32
Eastern	57				1
Subtotal				37	33
Pacific					
Northwest	61	1,448	2,719	3,196	5,462
Northeast	67	748	573	59	11
W. Central	71			4	10
E. Central	77	20	31		1
Southwest	81		45	70	66
Southeast	87			552	624
Subtotal		2,216	3,368	3,881	6,174
Antarctic					
Atlantic	48			424	188
Indian Ocean	58			103	28
Pacific	88				
Subtotal				527	216
Grand total		7,209	9,900	9,476	10,523

Source: FAO "Yearbook of Fishery Statistics," various years.

will make it easier to process krill. If successful, these innovations may justify an increase in Antarctic fishing effort in coming years.

In the Black Sea and inland waters, the Soviet fishery has stagnated. The Soviet Union has the potential to become a major producer of cultured fish, yet inland fisheries and cultured production have actually declined in recent years.

North America

The North American catch totaled 6.6 million t in 1986, a 5 percent increase over the 6.3 million reported in 1985. Data on the U.S. and Canadian fish catch are illustrated in Figure 10. Geographically, Mexico is located on the North American continent, but for sociological reasons, the Mexican catch has been included in the Latin American totals.

United States

The U.S. fish catch hit 4.9 million t in 1986, a 2 percent increase from the 4.8 million t reported in 1985[8]. While the overall catch increase was not large, specific fisheries exhibited some sharp fluctuations. Catches of Alaska pollock, shrimp, and crab increased, but catches of other important species such as menhaden, Pacific salmon, and cod declined. A variety of resource and marketing problems caused most of the declines. The salmon catch declined after records set in previous years, but 1986 was still above normal.

Canada

Canada's fisheries catch is slowly recovering, following a period of decline caused by heavy fishing off Canada's Atlantic coast. During 1986, Canadian fishermen caught 1.4 million t of fish and shellfish, an increase of 16 percent over the 1.2 million t caught in 1980. Canada's most important fishing grounds lie off the Atlantic coast, contributing 1.2 million t, or two-thirds of the total catch. Top groundfish and pelagic species landed in 1986, by quantity, were Atlantic cod (457,000 t), Atlantic herring (177,000 t), various flatfishes (85,000 t), redfish (75,000 t), and capelin (65,000 t). The top mollusk and crustacean species, by quantity, were scallops (56,000 t), snow crab (42,000 t), and lobster (35,000 t).

The International Court of Justice decision to award the disputed rich fishing grounds off Georges Bank to Canada (prior to this decision, both the United States and Canada were allowed to fish in the contested area off of Georges Bank), strict enforcement measures on fishing by domestic and foreign fleets in Canadian waters, and rigid management plans imposed on the stocks, have helped to increase Canadian catches in recent years, although many stocks remain depressed. Despite lower catches, the value of Canadian fishery landings has helped produce record incomes for Canadian fishermen, thanks to the strong demand for fishery products in the United States and on world markets. In 1986, the Canadian catch was valued at almost C$1 billion.

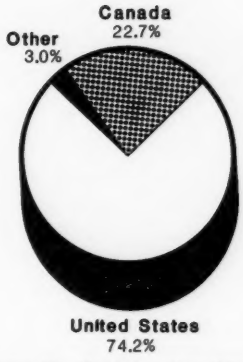


Figure 10.—North American fisheries catch, 1986; total for 1986 was 6.6 million t.

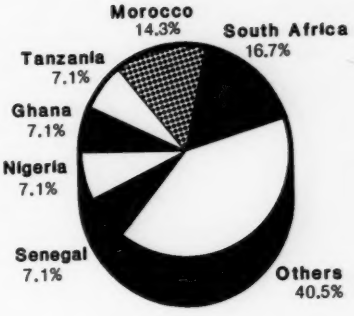


Figure 11.—African fisheries catch, 1986; total for 1986 was 4.2 million t.

Africa

The African fisheries catch has fluctuated between 4.1 and 4.4 million t since 1980. The 1986 catch was 4.2 million t, up slightly from the figure reported in 1985. African countries report a very small part of the world fisheries catch. In 1986, the African catch comprised only 5 percent of the world total, down 6 percent from 1980. The decline is a result of expanded fisheries in other areas, while African fisheries have experienced little growth. African catch data, however, do not include the extensive distant-water catch of the Soviet Union and other countries off the continent. The distant-water catch in 1985 totaled about 2.8 million t, which comprises about one-third of the total catch taken from African waters.

Seven countries (South Africa, Morocco, Tanzania, Ghana, Nigeria, Senegal, and Uganda) comprised nearly 60 percent of the 1986 African catch (Fig. 11). South Africa and Morocco are the two most important countries, and they accounted for about 25 percent of the African total, with 1986 catches of 0.7 million t and 0.6 million t, respectively. In 1985, Cape hake accounted for about 25 percent and anchovy about 40 percent of the South African catch; presumably, the composition of the 1986 catch is similar. In 1986, the sardine fishery supplied over 40 percent of the Moroccan catch, with mackerel accounting for nearly 20 percent. The remaining five countries each had 1986 catches in excess of 0.2 million tons each. South Africa's catch was stable, increasing by only 1 percent in 1986. Morocco's 1986 catch increased 25 percent, primarily because because its leading fishery for sardines increased an

[8]The preliminary U.S. catch data reported by FAO differs from "Fisheries of the United States, 1986," primarily because FAO calculates the live weight of mollusks while the United States calculated only the weight of the edible meats.

impressive 50 percent, according to statistics supplied by Morocco's Institute Scientifique des Peches Maritimes.

Middle East

Middle Eastern fishermen reported a catch of only about 1 million t in 1986. The small Middle Eastern catch is probably a combination of limited resources and lack of interest in developing the available resources. While small by world standards, the 1986 Middle East catch represented an increase of 25 percent over the 0.8 million t taken in 1980. Most of that increase occurred by 1982 and since then the catch has been stable at about the 1 million t level. The leading country in the region is Turkey, with a 1986 catch of 0.6 million tons. The Turkish catch has increased by nearly 35 percent from the 0.4 million t reported in 1980. European anchovy and horse mackerel made up about 70 percent of the catch in 1985.

Oceania

Fishermen in Oceania reported a catch of about 0.6 million t in 1986. The two major fishing countries are New Zealand (0.3 million t) and Australia (0.2 million t). New Zealand fishermen have reported steady growth since the early 1970's and achieved a new record catch in 1986. Much of the recent increase has come from expanding fishing effort to offshore fisheries and by careful management of the heavily fished coastal resources. Australian fishermen reported catch declines in 1985 and 1986. New management measures enacted to protect heavily fished stocks account for much of the decline.

Major Countries

World fisheries are dominated by 16 major countries which accounted for 75 percent of the catch in 1986 (Table 7). The two leading countries were Japan (11.9 million t) and the Soviet Union (11.1 million t). Other leading countries included China (7.3 million t), Chile (5.6 million t), Peru (5.3 million t), and the United States (4.9 million t). All have reported catch increases since 1980. The Soviet and Japanese increases are interesting as both countries heavily fish their own coastal waters and have also had to adjust to restrictions on their distant-water grounds by many coastal countries. The large increases reported by Peru and Chile were primarily due to a resurgence of the anchovy stock. While most of the principal fishing countries have reported catch increases in 1986, a few countries have reported declines: Norway (−10 percent), Iceland (−6 percent), and Thailand (−5 percent). The Norwegian trend in particular continues a trend begun in 1978. Major fishery developments in Japan, China, Chile, and Peru follow (U.S.S.R. developments were reported in a previous section).

Japan is the world's leading fishing nation, harvesting over 11.9 million t in 1986 (12.6 million t according to preliminary Japanese Government statistics), 13 percent of the world's catch. The 1986 catch is nearly a 4 percent increase over the 1985 catch of 11.5 million t and is second only to Japan's all-time record catch of 12 million t in 1984. Japan's catch has remained relatively stable since 1983, averaging about 11.7 million t annually.

Increasing enforcement of foreign 200-mile exclusive economic zones has kept Japan's distant-water catch fluctuating around 2.1 million t since 1979, with little possibility for growth. This factor has forced Japan to reevaluate its fishing strategy and to begin to fully develop its offshore and coastal resources, take a renewed look at aquaculture, and seek new fishing agreements with other countries. Although coastal production remained stable in 1986, marine culture and offshore fisheries grew by 9 percent and 5 percent, respectively. Sardines accounted for the largest increase in Japan's 1986 catch. Japanese fishermen caught about 4.5 million t, 9 percent more than in 1985. Sardine harvests in the waters off eastern Hokkaido and northern Honshu (both in the Sea of Japan and the Pacific) increased significantly in 1986. Other important species were Alaska pollock (1.4 million t), and Spanish mackerel (955,000 t); skipjack tuna registered the largest percentage increase in 1986, up 34 percent to 420,000 t.

China is the third largest fishing

Iceland's Fish Catch Steady, Value Climbs

Iceland's fisheries catch reached 1.7 million t in 1986, slightly less than Iceland's record 1985 catch. The value of the catch increased from $312 to $458 million. The cod catch again proved plentiful (366,000 t vs. 323,000 t) and the shrimp harvest rose by 44 percent from 25,000 t to 36,000 t, while the capelin catch (used mostly for reduction) declined from 993,000 t to 895,000 t. Large catches, high world prices, low oil prices, and a relatively low rate of inflation made 1986 a prosperous year for the Icelandic fishing industry. The debate over the pros and cons of fresh fish sales to Western Europe continued as representatives of the freezing industry expressed concerns over declining supplies of raw materials to meet demand for processed fishery products, mostly in the United States.

The U.S. market declined to 25 percent of the value of total Icelandic fish exports in 1986, while the continued growth in Icelandic sales to the United Kingdom makes it Iceland's most important market. The U.S. Embassy in Reykjavik has prepared an 11-page report reviewing Iceland's fisheries in 1986. The report includes sections on Iceland's fish, catch, the debate over fresh versus frozen fish sales, the growth of the United Kingdom market, foreign fishing in Icelandic waters, and the outlook for 1987. The report also includes statistical tables on Iceland's fish catch and how it is utilized, exports of fishery products by destination, exports by product form, exports to the United States, and Iceland's fishing fleet and number of fishermen. U.S. companies can obtain a copy of "Iceland's Fisheries, 1986" for $9.95 and a $3.00 handling fee (total of $12.95, personal checks or money orders only) by ordering report PB88-114566/GBA from NTIS, Springfield, Virginia 22161. (The handling fee is per order, regardless of how many reports are ordered.)

nation in the world, behind the Soviet Union, with a catch of over 7.3 million tons in 1986. The Chinese reported steady growth in all sectors of its fishing industry in 1986. The marine fisheries catch increased by 12 percent, to 3.9 million t. Principal marine species caught were croaker, hairtail, filefishes, mackerel, and shrimp. Equally spectacular growth was recorded by the freshwater fishery sector (+12 percent to 530,000 tons), marine aquaculture (+12 percent to 797,000 t), and freshwater aquaculture (+24 percent to 2.9 million t). Although China is a relative newcomer to high-seas fishing, its distant-water fleet has grown from about a dozen vessels fishing off West Africa in 1985 to over 30 fishing in the economic zones of seven countries by the end of 1986.

Despite this development, the prognosis is not overly optimistic for continued growth of China's marine fisheries sector. China's 1987 marine fisheries catch was expected to remain about the same as the 1986 catch. Chinese Government officials have predicted that fisheries production would reach 9 million t by 1990, with most of the increase coming from aquaculture. The breakthrough is expected to come in marine farming, with an estimated growth rate of over 11 percent per year. Major cultured marine species will include giant sea perch, shrimp, abalone, clams, mussels, scallops, sea cucumbers, and kelp. The main species used in freshwater culture are carp and tilapia.

Chile is the fourth most important fishing country with a 1986 catch of 5.6 million t. The fishing industry has been the fastest growing sector of the Chilean economy over the past 10 years. Officials were relieved that the 1986-87 El Niño did not adversely affect the 1986 catch, but were concerned about declining catches in 1987. Catches of the two most important species over the past few years (sardines and jack mackerel) declined in 1986, but were more than offset by increased anchovy catches. Most of the catch is reduced to fish meal, and Chile has become the world's leading fish meal exporter. Most companies are reporting good results, even though fish meal prices were substantially below 1980 price levels in constant dollars. While the large fish meal companies reported good results, Chilean fishermen reported declining catches in several traditionally important fisheries (shrimp, sea snails, sea urchins, langostinos, and several other valuable shellfish) in 1986. Other fishermen reported several promising developments in 1986, including expanded harvests of cultured salmon, small-scale surimi production, increased krill landings, and expanded landings of high quality fresh fish for the export market.

Peru was the fifth leading fishing country in 1986 with a catch of 5.3 million t. Peruvian fishermen reported a massive 25 percent increase over their 1985 catch. The increase was primarily due to the resurgence of anchovy stocks. Fishermen in northern Peru were affected by the 1986-87 El Niño beginning in late 1986. Fishermen along the central and southern coast did not begin to report catch declines, however, until mid-1987. (It is not known to what extent the declining 1987 catches in Peru and Chile were due to El Niño or other factors such as overfishing.) While the El Niño was affecting 1987 catches, most of Peru's reduction plants and canneries reported substantially improved results for 1986. The Government gave special priority to efforts aimed at increasing the catch of edible fish to increase supplies to the domestic market. An agreement was signed with Cuba to permit Cuban distant-water trawlers to operate in Peruvian waters and land their catch in Peru. The Government also provided funding so that the state food fish company, the Empresa Publica de Servicios Pesqueros (EPSEP), could acquire its own fishing fleet. Even though catches increased sharply, several long-standing problems plagued the industry in 1986, including labor strife, unused canning capacity, the inability to reach an agreement with the Soviets on joint ventures, high interest rates, low fish meal prices, and a sharp decline in scallop catches.

Aquaculture

While some have predicted that aquaculture, sometimes referred to as the "blue revolution," would rapidly replace wild capture fisheries (which many expected to decline), this has not proven to be the case. Capture fisheries have not declined, nor has aquaculture begun to account for more than a small share

Atlantic Canada's Aquaculture Industry

Atlantic Canada's 33 commercially viable fish farms produced 1,800 t of mussels, 500 t of salmon, and 110 t of trout in 1986. The leading province in Atlantic Canada's aquaculture industry is Nova Scotia (11 farms), followed by New Brunswick (9 farms), Prince Edward Island (6-8 farms), and Newfoundland (5 farms). In 1986, these aquaculture facilities generated about C$9 million and it is projected that this amount could be increased 30 times in 10 years.

Many Canadian fish farmers are short on working capital and technical knowledge. Provincial governments have limited themselves to providing technical aid, but not funding. Future expansion of aquaculture facilities is expected to be opposed by homeowners living near potential aquaculture sites. The region has limited access to processing facilities and the severity of Canadian winters are factors that need to be examined before Atlantic Canada's aquaculture industry can meet its full potential. The U.S. Consulate General in Halifax has prepared a 9-page report reviewing Atlantic Canada's aquaculture industry. The report includes sections on the scope of the industry, aquaculture legislation, funding programs, public opposition, technical problems, and comments. The report also includes list of Federal and provincial legislation in the field of aquaculture. U.S. companies can obtain a copy of "Atlantic Canada's Aquaculture Industry, 1986" for $9.95 and a $3.00 handling fee (total of $12.95, personal checks or money orders only) by ordering report PB88-114574/GBA from NTIS, Springfield, VA 22161. (The handling fee is per order.)

of the world's fisheries production. The combined total of cultured production and freshwater fisheries was only 8.4 million t in 1985, about 10 percent of the world total[9]. For the foreseeable future, fishermen will be able to catch most species in larger quantities and more cheaply than fish farmers will be able to culture them. Fish farmers have, however, reported some successes. The greatest commercial successes have come from efforts to culture high value species for luxury food markets. Efforts to culture salmon and shrimp have been particularly noteworthy. The Branch of Foreign Fisheries Analysis estimates that fish farmers harvested about 70,000 t of salmon and 310,000 t of shrimp in 1986. While small in quantitative terms, these are particularly valuable species and many observers believe that production will increase far beyond current levels. Other fish farmers have reported success with catfish, trout, mullet, oysters, and mussels. Experimental work is currently underway on a wide range of other species. In some cases, however, fish farmers will not increase the total world supply of food. Many fish farmers, for example, use low-value fish to feed the species which they are culturing. The operation is profitable, but may not result in a net increase of edible commodities. Several developing countries have pursued projects to culture tilapia, carp, mullet, and various other species. Some of these projects have resulted in increases of edible commodities. Increases in carp and tilapia catches and Asian catches of a wide variety of freshwater species suggest that aquaculture is gradually increasing the production of edible fish in developing countries, although statistical data separating aquaculture and freshwater fisheries is not readily available.

[9]Precise data on cultured harvests are not readily available, but the Branch believes that a rough estimate of aquaculture trends can be obtained by following catch trends in inland areas reported by FAO.

Potential

The world potential fish catch of edible species has been debated for some years. One widely accepted—although not undisputed—estimate in the world fisheries community, is that the world catch will continue to increase until about the year 2000 when it could total 100-120 million t of conventional species, a figure that many experts believe is the approximate maximum world yield. These estimates may have to be revised. If current trends continue, the 100 million t figure could be reached as early as 1990. However, several Latin American countries have reported declining catches in 1987, principally due to El Niño. Year-end results for the entire world may be about the same as or a small decline from 1986 figures.

Projections of future fish catches, however, are tenuous at best. A wide variety of factors will affect actual increases: Fuel prices, interest rates, national management and development measures, fish prices, technological developments, interest rates, and other developments. Many biologists currently believe that conventional stocks will not support catches significantly beyond the 120 million t level.

Further increases could, however, come from species not currently being utilized. If profitable ways of utilizing Antarctic krill, for example, could be developed, the world catch could expand significantly beyond the 100-120 million t level. Some experts have projected that an intensive krill fishery could double or triple the world catch, but more recent assessments have been more conservative. The 1985 krill catch was less than 0.2 million tons, mostly taken by the Soviets who have been

The Latin American Shrimp Culture Industry

Latin America is a leading world producer of cultured shrimp. Shrimp farmers in the region harvested over 50,000 t of shrimp in 1985, a 40 percent increase over the 37,000 t of shrimp cultured in 1985. Ecuador dominates the region's shrimp culture industry—nearly 85 percent of the Latin American harvest was produced in that country. The industry continues to expand in Ecuador and is rapidly growing in several other countries as well. Prospects for the development of important shrimp culture industries are especially good in Brazil and Colombia.

Ecuador reported major increases in pond harvests during 1987. Several other countries also reported substantial, if less spectacular, 1987 harvests. Based on these increases and continuing expansion of the industry, the NMFS Branch of Foreign Fisheries Analysis conservatively estimates that the cultured shrimp harvest in Latin America could reach nearly 115,000 t by 1990. That projection is based primarily on one country (Ecuador) and one species (*Penaeus vannamei*). As more countries enter the industry and technical advances enable farmers to increase yields and perhaps use different species of shrimp, it is likely that production will continue to increase during the 1990's. Many observers are unsure, however, about the impact of rising world production on the international shrimp market. If substantially lower prices result from the increased production, profit margins could be significantly affected. If so, many farmers may have to adjust their production and expansion plans.

The NMFS Branch of Foreign Fisheries Analysis has prepared an 80-page report reviewing the current status of the shrimp culture industry in Latin America. The report covers: harvest levels, the regional importance, traditional fisheries, quality/size control, species, government support, postlarval seedstock, variables (economic, technical, environmental, and political), investments, and a separate section on each country. The report includes extensive statistical appendices on harvests and exports and is a slightly updated version of the Latin American section in the U.S. Department of Commerce's "Aquaculture and Capture Fisheries: Impact in U.S. Seafood Markets," published earlier in 1988. U.S. companies can obtain a copy of "Latin American Shrimp Culture Industry, 1986-90" for $14.95 and a $3.00 handling fee (total $17.95, personal checks or money orders only) by ordering report PB88-210745/GBA from NTIS, Springfield, VA 22161.

reducing fishing effort in recent years.

Even within existing catch levels, the production of edible products could be substantially increased. Production of edible products from fisheries could be expanded by better utilizing existing catches. About 30 percent of the catch is currently used for reduction fisheries producing fish meal and oil. Animal feed, of course, is not lost to human consumption as most of the animals will be slaughtered for food. The amount of protein available, however, would be increased if the fish were consumed directly instead of being used for fish meal production. Perhaps as much as 10 percent of the world catch is lost as a result of poor handling and processing procedures. Many fishermen discard large quantities of unwanted fish at sea. Suggestions concerning utilization of fish currently reduced to fish meal, landing species currently discarded, improved handling, and other measures to increase food production are often presented in unrealistic terms. They must be tempered by economic reality. Processors must be able to produce a product that will appeal to consumers at affordable prices. (Source: IFR-87/63.)

Argentine Fisheries See Good Growth

Argentine fishing companies reported an excellent year in 1986. Higher international prices and the emergence of Brazil as a major buyer in the third quarter of 1986 were crucial factors in Argentina's improved 1986 export performance. Argentine fishery exports totaled $219 million in 1986, an 110 percent increase over the $104 million exported in 1985. Several long-term difficulties still plagued the Argentine fishery industry in 1986: An outdated fleet, limited port facilities, outmoded processing plants, and inefficient infrastructure, all of which prevented an even better performance. The Argentine Government has instituted some assistance programs for the fishing industry. Several companies were able to put vessels back into service during 1986 by taking advantage of a new credit line offered by the Argentine Development Bank which was designed to promote the renovation of the fleet. The Government also signed fishery agreements with Bulgaria and the Soviet Union which, it hopes, will result in export sales to the Soviet Union and Eastern Europe.

The U.S. Embassy in Buenos Aires has prepared a 24-page report reviewing the current status of Argentina's fishing industry. The report includes sections on landings, industry performance, economic conditions, foreign fishing, port facilites, fishing fleet, markets, and production. The report also includes extensive tables, including data on catch, exports, biomass, maximum sustainable yields, and fleet. There is also a list of Argentine fishery associations. U.S. companies can obtain a copy of "The Argentine Fishing Industry, 1986" for $11.95 and a $3.00 handling fee (total $14.95, personal checks or money orders only) by ordering report PB88-114475/GBA from NTIS, Springfield, VA 22161.

Open-Sea Salmon Farm Is Started off Norway

What Norwegian authorities describe as the world's first fish farm for salmon in the open sea, began operation in late April to the west of the island of Værøy, one of the Lofoten Islands off north Norway. The small fry have to be set out in June, and the first artificially cultivated deep sea salmon should be on the market next year, reports Norinform.

The development of the farm, budgeted at US$670,000, was planned in cooperation with industry in north Norway, and based on the technology used in the offshore sector. The depth of water at the farm will be more than 100 m, and waves up to 13 m in height have been measured at the location. The plant has therefore been dimensioned to tolerate wave heights up to 22 m. The facilities will comprise 20 enclosures firmly anchored to the seabed by heavy weights, and totalling 23,000 m^3, vs. the normal coastal farm size of 8,000 m^3. A ship anchored at the plant will steer operations.

The initiators took advantage of the fact that the location of the farm is outside the 4-mile concession limit. A spokesman for the Ministry of Fisheries has stated that the ministry may consider changes in legislation so that farms outside normal 4-mile limits also must comply with regulations. Free access for the establishment of fish farms in open sea conflicts with the intention of the law, which is to regulate such establishments out of consideration to public interests, says Gunnar H. Gundersen of the Ministry of Fisheries.

New NMFS Scientific Reports Published

The publications listed below may be obtained from either the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402 or from the National Technical Information Service, Springfield, VA 22151. Writing to the agency prior to ordering is advisable to determine availability, order numbers, and price.

NOAA Technical Report NMFS 54. Gooch, Janet A., Malcolm B. Hale, Thomas Brown, Jr., James C. Bonnet, Cheryl G. Brand, and Lloyd W. Regier. **"Proximate and Fatty Acid Composition of 40 Southeastern U.S. Finfish Species."** June 1987, iii + 23 p., 43 tables.

ABSTRACT

This report describes the proximate composition (protein, moisture, fat, and ash) and major fatty acid profiles for raw and cooked samples of 40 southeastern finfish species. All samples (fillets) were cooked by a standard procedure in laminated plastic bags to an internal temperature of 70°C (158°F). Both summarized compositional data, with means and ranges for each species, and individual sample data including harvest dates and average lengths and weights are presented. When compared with raw samples, cooked samples exhibited an increase in protein content with an accompanying decrease in moisture content. Fat content either remained approximately the same or increased due to moisture loss during cooking. Our results are discussed in reference to compositional data previously published by others on some of the same species. Although additional data are needed to adequately describe the seasonal and geographic variations in the chemical compositions of many of these fish species, the results presented here should be useful to nutritionists, seafood marketers, and consumers.

NOAA Technical Report NMFS 55. Krzynowek, Judith, and Jenny Murphy. **"Proximate Composition, Energy, Fatty Acid, Sodium, and Cholesterol Content of Finfish, Shellfish, and Their Products."** July 1987, iii + 53 p., 2 tables.

ABSTRACT

This document contains data concerning the proximate composition and energy, fatty acid, sodium, and cholesterol content of finfish, shellfish, and their products, as listed

The Management of Migratory Fishes

"Multi-jurisdictional Management of Marine Fisheries." edited by Richard H. Stroud, constitutes the "Proceedings of the Eleventh Annual Marine Recreational Fisheries Symposium" held in Tampa, Fla., in May 1986, and is published by the National Coalition for Marine Conservation, Inc., Savannah, Ga. Frank E. Carlton set the tone for the symposium with his introductory address "Fish Know No Boundaries," which was followed by then-NOAA Administrator Anthony J. Calio who assessed the Federal role in marine fisheries. Carl E. Nettleton then addressed the development of a fisheries resource management plan that would achieve optimum population levels. As with the earlier symposia, this one divided the presentations into several Panels: 1) Putting the challenge of fisheries management into perspective, 2) inter-jurisdictional problems, 3) case studies, 4) new directions for management, 5) to preempt or not, 6) NMFS, Councils, and the Act (MFCMA), ending with summaries of each panel's by the panel chairmen.

In large part, the presentations address the problems and opportunities in managing marine and anadromous fishes under the MFCMA by the various Councils; another important aspect covered was management by the creation of habitat for certain species. In addition, some very controversial issues were aired, including Federal preemption of state authority, Federal saltwater fishing licenses, the Native American role in fisheries management, and various interjurisdictional fisheries problems. In addition, floor discussions and panel debates are published which help air various sides of the issues. Case studies presented included discussions of state-Federal management of red snapper and gag; multi-state-Federal management of king mackerel, and international management of highly migratory tuna and billfishes. Unindexed, the hardbound volume is available from the International Game Fish Association, 3000 East Las Olas Blvd., Ft. Lauderdale, FL 33316-1616 for $15.00.

Game Fish Trophies, Articles Published

"World Record Game Fishes 1988" has been published by the International Game Fish Association, 3000 East Las Olas Blvd., Ft. Lauderdale, FL 33316-1616, under the direction of Elwood K. Harry. This year the "articles" section is devoted to presentations by four noted outdoor writers on some of the world's finest angling areas: Alaskan angling by Chris Batin, Hawaiian offshore fishing by Jim Rizzuto, Australia's Great Barrier Reef trophies by Peter Goadby, and America's blue-ribbon trout streams by A. J. McClane.

Also rewritten this year and considerably updated is the game fish species section, about 6 pages of data on popular fishes and which includes many new and improved illustrations, a number by NMFS biologist-artist Susan Smith.

in 228 articles published between the years 1976 and 1984. Also included is a systematic index of the species as referenced in this document listed alphabetically by scientific names.

NOAA Technical Report NMFS 56. Hirth, Harold F., and Larry H. Ogren. **"Some Aspects of the Ecology of the Leatherback Turtle *Dermochelys coriacea* at Laguna Jalova, Costa Rica."** July 1987, iii + 14 p., 13 figs., 12 tables.

ABSTRACT

The ecology and reproductive biology of the leatherback turtle (*Dermochelys coriacea*) was studied on a high-energy nesting beach near Laguna Jalova, Costa Rica, between 28 March and 8 June 1985. The peak of nesting was between 15 April and 21 May. Leatherbacks here measured an average 146.6 cm straightline standard carapace length and laid an average 81.57 eggs. The eggs averaged 52.12 mm diameter and 85.01 g weight. Significant positive relationships were found between the carapace lengths of nesters and their clutch sizes and average diameter and weight of eggs. The total clutch weighed between 4.02 and 13.39 kg, and yolkless eggs accounted for an average 12.4 percent of this weight. The majority of nesters dug shallow (<24 cm) body pits and spent an average 81 minutes at the nest site. A significant number of clutches were laid below the berm crest. In a hatchery 42.2 percent of the eggs hatched, while in natural nests 70.2 percent hatched. The average hatchling carapace length was 59.8 mm and weight was 44.6 g. The longevity of leatherback tracks and nests on the beach was affected by weather. One nester was recaptured about 1 year later off the coast of Mississippi. Egg poaching was intense on some sections of the Costa Rican coast. Four aerial surveys in four different months provided the basis for comparing density of nesting on seven sectors of the Caribbean coast of Costa Rica. The beach at Jalova is heavily used by green turtles (*Chelonia mydas*) after the leatherback nesting season. The role of the Parque Nacional Tortuguero in conserving the leatherbak and green turtle is discussed.

NOAA Technical Report NMFS 57. Brodeur, Richard D., Harriet V. Lorz, William G. Pearcy. **"Food Habits and Dietary Variability of Pelagic Nekton off Oregon and Washington, 1979-1984."** July 1987, iii + 32 p., 1 fig., 32 tables.

ABSTRACT

The food habits of 20 species of pelagic nekton were investigated from collections made with small-mesh purse seines from 1979-84 off Washington and Oregon. Four species (spiny dogfish, *Squalus acanthias*; soupfin shark, *Galeorhinus zyopterus*; blue shark, *Prionace glauca*; and cutthroat trout, *Salmo clarki*) were mainly piscivorous. Six species (coho salmon, *Oncorhynchus kisutch*; chinook salmon, *O. tshawytscha*; black rockfish, *Sebastes melanops*; yellowtail rockfish, *S. flavidus*; sablefish, *Anoplopoma fimbria*; and jack mackerel, *Trachurus symmetricus*; consumed both nektonic and planktonic organisms. The remaining species (market squid, *Loligo opalescens*; American shad, *Alosa sapidissima*; Pacific herring, *Clupea harengus pallasi*; northern anchovy, *Engraulis mordax*; pink salmon, *O. gorbuscha*; surf smelt, *Hypomesus pretiosus*; Pacific hake, *Merluccius productus*; Pacific saury, *Cololabis saira*; Pacific mackerel, *Scomber japonicus*; and medusafish, *Icichthys lockingtoni*) were primarily planktonic feeders. There were substantial interannual, seasonal, and geographic variations in the diets of several species due primarily to changes in prey availability. Juvenile salmonids were not commonly consumed by this assemblage of fishes.

Revised and updated, too, are the sections on international angling rules and world record requirements—particularly with the new additions to the world record eligible list like the queenfish, Japanese seabass, kahawai, bluefin trevally, and mutton snapper. For avid anglers, the "meat" of the publication is the listings of world angling trophies (freshwater and saltwater), plus fly-rod and all-tackle trophies and membership in the Thousand Pound Club and the 5, 10, and 20-to-1 clubs. Also provided are lists of state game fish record keeping agencies and organizations, worldwide recordkeeping organizations, and tag-and-release programs. The 320-page paperbound volume is available from the publisher for $9.75 (U.S.) and $11.95 (foreign).

Pacific Salmon and Their Management

Publication of **"Salmon Production, Management, and Allocation,"** edited by William J. McNeil, has been announced by the Oregon State University Press, 101 Waldo Hall, Corvallis, OR 97331-6407. Subtitled "Biological, Economic, and Policy Issues," it is a compilation of 20 papers presented at the World Salmonid Conference which was held in October 1986 in Portland, Oreg., by the Salmonid Foundation. The authors, ranging from scientists and aquaculturists to economists, fishery managers, and lawyers, have presented a wide variety of authoritative papers relating to the integration of aquaculture into the overall production of Pacific salmon, and the topics range from salmon biology and ecology to pertinent social and economic issues.

Lawyer Alfred A. Hampson discusses the laws and property rights relating to salmon ranching by public and private entities, and he suggests several legislative needs. A thorough review of Japanese salmonid programs, salmon supplies, and public policy is given by Yoshio Nasaka, while Frank Gjerset reviews the status and outlook for Norwegian Atlantic salmon farming, comparing characteristics of that industry with those of the U.S. catfish farming industry. Other articles include changes in the catch pattern of North American salmonids by Japan's high seas fleet by Colin Harris, while William Pearcy discusses factors affecting survival of coho salmon off Oregon and Washington, and Ernest Salo looks at the chum salmon as an indicator of ocean carrying capacity. And, Donald Rogers reviews the timing and size composition of Bristol Bay smolt migrations and the effects on distribution and survival at sea.

Additional papers discuss the problems involved in managing mixed-stock salmon fisheries; the culture, allocation, and economic value of Pacific salmon in the Great Lakes; conservation and allocation decisions in fishery management, the impacts on coastal communities of recreational-commercial fishery allocation of salmon; salmon markets, economics of recreational salmon fishing, potential hazards for spreading of infectious disease by transplanted fish, and directed and inadver-

tent genetic selection in salmonid culture.

Salmon harvests, after dropping to less than half their historic levels, began increasing nearly two decades ago, and are again approaching their historic levels. While naturally produced salmon still contribute most to the world's salmon harvest, aquaculture production is growing rapidly. This book examines many important issues, some very controversial, and should be of interest to those involved in salmon research, culture, marketing, and management. Indexed, the 194-page hardbound volume is available from the publisher for $31.95 postpaid.

The Marine Fisheries of Indonesia and Thailand

The International Center for Living Aquatic Resources Management (ICLARM), Manila, Philippines, has produced excellent new reviews on the fisheries of Thailand and Indonesia. **"Indonesia Marine Capture Fisheries"** by C. Bailey, A. Dwiponggo, and F. Marahudin, ICLARM Contribution 338, is part of the ICLARM Studies and Reviews Series 10. The authors have winnowed existing literature to provide a fine descriptive overview of that nation's fisheries and, in the process, pointed out areas in need of greater study and research. Following reviews of the nation's marine fisheries and fishery resources, the authors address fisheries management and development policies and programs, economics, fish marketing and distribution, socioeconomic factors of small-scale fisheries, and needs for further research. Included in the 196-page paperbound volume is an extensive list of references. The volume is available either from ICLARM at US$9.50 (surface mail) or US$18.00 (airmail) or, in the United States, from International Specialized Book Services, P.O. Box 1632, Beaverton, OR 97075 at $18.00.

ICLARM Technical Reports 17 is **"Growth, Mortality and Recruitment of Commercially Important Fishes and Penaeid Shrimps in Indonesian Waters"** by A. Dwiponggo, T. Hariati, S. Banon, M. L. Palomares, and D. Pauly. Data is presented in 61 plates and tables covering fishes ranging in size from 10 cm (*Secutor ruconius*) to 80 cm (*Katsuwonus pelamis*) and for areas from Jakarta Bay to the Arafura Sea. Altogether, 52 stocks of fish are covered, including 36 species, 21 genera, and 15 families of bony fishes as well as 9 annual cohorts from the Arafura Sea stock of the shrimp *Penaeus merguiensis*. Presented are estimates of von Bertalanffy growth parameters which were derived through application of the ELEFAN I program to length-frequency data from the various fishes. Derived quantities such as total, natural, and fishing mortality estimates, as well as selection and recruitment patterns were then obtained by application of the ELEFAN II program to the same length-frequency data. Some generalizations on the status of the stocks are presented, particularly for the demersal fishes off the north coast of Java and on *P. merguiensis* in the Arafura Sea. Paperbound, the 91 page volume is priced at US$4.50 (surface mail) and US$8.50 (airmail and the U.S. price from ISBS).

ICLARM Studies and Reviews 14 is **"The Economics and Management of Thai Marine Fisheries"** by Theodore Panayotou and Songpol Jetanavanich. Like number 10, this is a fine review of the relevant literature and presentation of data on Thai fisheries—one of the world's ten largest, having a fleet of more than 20,000 modern vessels and a harvest of around 2 million metric tons. Thailand fishermen supply 20 kg/capita of fish for a population of 50 million and earn the nation about $500,000,000 in foreign exchange annually. The authors document the profitability of the trawl fishery, small-scale fishermen's economic problems, overfishing in the Gulf of Thailand, and the problems and potential in the nation's management and enforcement capabilities. It also suggests a number of solutions to Thai fisheries problems. Price of the 82-page paperbound volume is US$5.00 (surface mail) and US$9.00 (airmail—and the ISBS price). ICLARM recommends orders to them be for airmail delivery owing to surface mail delays of several months and potential losses in transit.

ICLARM has also published ICLARM Bibliographies 7, "A Bibliography of Trochus (*Trochus niloticus* L.) (Gastropoda: Trochidae), by Warwick J. Nash, updating the annotated bibliography of Gail and Devambez of 1958. It includes over 130 citations, many hard to locate in conventional databases, along with subject and geographic indexes (price not listed).

What Is Ecology?

When Danish marine ecologist and professor Tom Fenchel received the first annual "Excellence in Ecology" award from the Ecology Institute, Oldendorf/Luhe, FRG, he found a string attached: He was expected to serve science and society by authoring a book along the aims of the Institute. Thus, the first book in the new series "Excellence in Ecology" is Fenchel's **"Ecology—Potentials and Limitations,"** edited by O. Kinne, Institute Director. Fenchel's book is aimed primarily at other ecologists, hoping to engage them in a debate on the definition of ecology, as well as to present central problems and results of ecology to biologists at large and to other scientists.

The author complains that ecology, per se, seems to be a "diffuse" or an "immature" science that many people would define differently, often in light of their own specialization. He notes that ecology differs from most other natural sciences in seemingly lacking a central core of ideas, concepts, methods, and goals upon which everyone can agree. Fenchel then strives to present what he sees as the "core" of that discipline, and to provide a synthesis of the field.

In so doing, the author begins with a brief historical background of contemporary ecology and presents his view of how ecology should be defined: "As the study of the principles which govern temporal and spatial patterns for assemblages of organisms." He discusses different types of theoretical models used in ecology and attempts to delimit ecology relative to other biological disciplines, such as natural history, evolutionary biology, physiology, behavioral biology, and biogeochemistry.

Section III, entitled "Concepts, ideas, and problems in ecology," presents a more detailed look at the "gist" of ecology—scales of size and time among living things, flow of energy and materials, resource competition, interactions between species populations, structure of biotic communities, evolution of life cycles, and more. The following section (IV) then presents selected examples to illustrate several of the general ecological principles given in the previous section.

Section V, "Ecology and society," is concerned with applied ecology, and here Fenchel warns his peers that, while applied research is necessary and desirable, some aspects of ecology may be especially vulnerable to intellectual corruption. This is an especially thoughful and interesting book, made all the more so because of the author's marine science background and the examples woven through it. The 186-page hardbound volume is available from the publisher, Ecology Institute, D-2124 Oldendorf/Luhe, Federal Republic of Germany; price is DM7, or about US$40 (depending on the exchange rate).

A Trolling Handbook for South Pacific Fishermen

"Trolling Techniques for the Pacific Islands," by G. L. Preston, L. B. Chapman, P. D. Mead, and P. Taumaia and illustrated by S. E. Belew is Handbook No. 28 of the South Pacific Commission, Noumea, New Caledonia. The handbook was developed as a training aid for the Pacific Island region to document some of the specialized and often unwritten knowledge and practical experience gleaned by SPC staff over the years, and the latter may be its greatest strength. The volume is thoroughly and well illustrated and clearly documents many of the techniques learned or proven in that region over the years.

Following a basic introduction to Pacific trolling, the authors illustrate, chapter by chapter, all aspects of that fishery for the individual small-scale fisherman: Vessel considerations and preparation (fish containers, trolling booms, handreels, gaffs, etc.); preparation of trolling lines and gear; types of baits and lures and their rigging; trolling conditions and techniques; fishing action—working the lines, the strike, handling fish on fixed lines and handreels, and boating and care of the catch; care of the boat and fishing gear and recordkeeping; coping with problems—injuries, accidents, breakdowns, signalling, and sea survival techniques. Another chapter describes the habits and characteristics of commonly caught species; appendices illustrate pole trolling in the Pacific Island tradition and give suggestions for additional sources of information. All in all, the book is an excellent guide for the region's fishermen. Paperbound, the 162-page volume is available from the SPC (price not listed).

Drying of Fish With Solar Energy

Drying fish is an ancient preservation method that is still of considerable importance, especially in tropical regions. Aspects of this, and appropriate techniques and research, are addressed in **"Solar Drying in Africa,"** subtitled Proceedings of a Workshop held in Dakar, Senegal, 21-24 July 1986, edited by Michael W. Bassey and O. G. Schmidt and published by the International Development Research Center, P.O. Box 8500, Ottawa, Canada K1G 3H9. Contributions address a range of studies including papers reviewing solar energy available in typical tropical locations and applications of solar energy in food production, and construction and performance of solar crop dryers. Studies are presented on the evaluation of various types of solar dryers—solar concentrator/dryer, flat-plate collector/dryer, and flat-plate collector/dryer-storage unit.

Another paper specifically addresses appropriate technology for solar drying of salt fish and fermented fish. Others discuss the application of natural- and forced-convection style solar dryers to various fishes and fish products, along with other agricultural commodities. Additional reports address the outlook for solar drying of fish in The Gambia, how solar drying can reduce post-harvest fish losses, and a variety of problems and developments in solar drying in African nations. The 286-page paperbound volume, IDRC-255e, is available from the IDRC (price not listed).

MACROALGAE AND ENERGY PRODUCTION

The energy crisis of the early 1970's spawned many efforts to gain new sources of energy; some went for deeper deposits of oil and gas, some turned to coal, and some, as the following volume attests, went to the sea, in this case to cultivate seaweeds for energy conversion. **"Seaweed Cultivation for Renewable Resources,"** edited by K. T. Bird and P. H. Benson, and published as volume 16 in the series "Developments in Aquaculture and Fisheries Science" by Elsevier Science Publishing Company Inc., 52 Vanderbilt Avenue, New York, NY 10017, goes well beyond simply reviewing seaweed as an energy source. Many of the advancements reported initially in various (and sometimes hard to locate) symposia, conference proceedings, technical reports, and journal articles are here condensed, synthesized, and collected into one volume.

The first four chapters deal with the giant kelp, *Macrocystis pyrifera*, the species which was the primary candidate in most marine biomass studies. Indeed, chapter 1 provides both a history of the giant kelp biomass program but reviews the early and current industrial development and utilization of kelp. Chapter 2 then describes successes and failures of the early efforts to cultivate kelp on offshore structures, while chapter 3 reviews the work on growing kelp in nearshore farm environments. Chapter 4 discusses the optimization of kelp growth in marine farms.

Chapter 5 then describes *Laminaria* culture in the far east and in North America, along with the idea of multicropping with a summer-adapted seaweed species for improved year-round productivity. C. K. Tseng then reviews the Chinese kelp cultivation industry and its implications for biomass energy systems.

Many other less well known seaweeds, of course, are adapted to warm water

habitats and the biology of such important tropical and subtropical species are reviewed by Clinton Dawes in chapter 7, along with physiological considerations in relating to their cultivation. Biomass production of *Gracilaria* in outdoor cultivation systems in Florida is discussed in chapter 8, along with factors influencing *Gracilaria* yield, research on other species of macroalgae (i.e., *Sargassum* and *Ulva*), and a discussion of other uses for biomass of macroalgae (i.e., hydrocolloid production, wastewater treatment, fish feed, fodder, and fertilizer). Additional chapters discuss tissue culture of seaweeds, nitrogen fixation in marine communities and its potential role in seaweed cultivation, biological gasification of marine algae, microbial degradation of marine biomass, cost analyses of energy from marine biomass, and a commercialization strategy for nori culture in Puget Sound, Washington. Each chapter carries a literature cited section, and a separate section at the end of the book presents a list of 78 technical reports on marine biomass for energy, along with suggested sources of additional data or reports (i.e., symposia proceedings, etc.).

The key to the future of marine biomass programs, the editors note, must be crop yield improvements, perhaps through breeding and genetic analysis to produce new crop candidates. While western biomass to energy programs are now idle, they have generated much important and useful information which this volume handily reviews. Indexed the 381-page hardbound volume is available from the publisher.

Toward a Sociology of Natural Science

Publication of **"Social Science in Natural Resource Management Systems,"** edited by Marc L. Miller, Richard P. Gale, and Perry J. Brown, as part of the "Social Behavior and Natural Resources Series, has been announced by Westview Press, 5500 Central Avenue, Boulder, CO 80301. Some natural resource agencies seem to have integrated social scientists and their studies into research and management programs and policies more than others and this volume examines a variety of such situations—including marine fisheries.

Presentations are divided into several parts: Following an overview of natural resource management systems, the section "Roles of Science" presents a discussion of natural resource sociology, utilizing forests and marine fisheries as the examples, and the authors suggest a need to strengthen natural resource sociology to be better able to respond to shifting social, political, and economic situations. Other contributions in this section examine the partnership between social scientists and park and resource managers, the practice and promise of social science in the U.S. Forest Service, the integration of social science into wildlife management, and the sociology of the forestry and marine fisheries sciences in the Pacific Northwest.

A third section, "Applications of Social Science," has chapters on park planning in Canada, planning and managing visitor activity in Canadian National Parks, social carrying capacity research in a wilderness area, and an interesting discussion of emotions in environmental decision making—rational planning vs. the passionate public. A final section presents reports on social science research and recommendations on three public land issues.

Early on, the editors present their concept of a natural resource management system (NRMS), a four-part system with the following elements: 1) natural resources, 2) management bureaucracies, 3) profit-seeking industries, 4) and diverse publics (organized and unorganized), in which they establish all four components as fair objects of social science research. In addition, they portray "management bureaucracies" as "embedded within" the NRMS, rather than as a "detatched steward." They then utilize this NRMS as a basis for comparing resource management experiences in later chapters. The book is aimed primarily at social scientists who, the editors say, "must establish their own niche in natural resource management systems." But it would also be of interest to resource biologists and managers who must also deal with social as well as resource issues on a daily basis. Paperbound, the 265-page book is available from the publisher for $22.50.

Marine Ecology Text Updated

The second edition of **"An Introduction to Marine Ecology"** by R. S. K. Barnes and R. N. Hughes has been considerably revised and updated by authors and republished by Blackwell Scientific Publications, Inc., 667 Lytton Avenue, Palo Alto, CA 94301. The volume is intended for students with a knowledge of basic ecology, but who are venturing into marine ecology for the first time. Thus, each chapter treats a distinct process or subsystem of the ocean.

Following a general introductory chapter on the nature and global distribution of marine organisms and their habitats, the authors succinctly review the planktonic system of surface waters, the benthos of continental shelf and littoral sediments; salt marshes, mangrove swamps and seagrass meadows; rocky shores and kelp forests; coral reefs, pelagic and benthic systems of the deep sea; fish and other nekton, ecology of life histories, speciation and biogeography, the marine ecosystem as a functional whole, and human exploitation and interference. Indexed, the 351-page volume is available in paperbound ($29.50) and hardbound ($67.50) versions from the publisher, and it provides a good concise introduction to the field.

Editorial Guidelines for the *Marine Fisheries Review*

The *Marine Fisheries Review* publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under a completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

Style

In style, the *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 12, "A List of Common and Scientific Names of Fishes from the United States and Canada," fourth edition, 1980. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

Tables and Footnotes

Tables and footnotes should be typed separately and double-spaced. Tables should be numbered and referenced in text. Table headings and format should be consistent; do not use vertical rules.

Literature Cited

Title the list of references "Literature Cited" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, and the year, month, volume, and issue numbers of the publication. Unpublished reports or manuscripts and personal communications must be footnoted. Include the title, author, pagination of the manuscript or report, and the address where it is on file. For personal communications, list the name, affiliation, and address of the communicator.

Citations should be double-spaced and listed alphabetically by the senior author's surname and initials. Co-authors should be listed by initials and surname. Where two or more citations have the same author(s), list them chronologically; where both author and year match on two or more, use lowercase alphabet to distinguish them (1969a, 1969b, 1969c, etc.).

Authors must double-check all literature cited; they alone are responsible for its accuracy.

Figures

All figures should be clearly identified with the author's name and figure number, if used. Figure legends should be brief and a copy may be taped to the back of the figure. Figures may or may not be numbered. Do not write on the back of photographs. Photographs should be black and white, 8 × 10 inches, sharply focused glossies of strong contrast. Potential cover photos are welcome, but their return cannot be guaranteed. Magnification listed for photomicrographs must match the figure submitted (a scale bar may be preferred).

Line art should be drawn with black India ink on white paper. Design, symbols, and lettering should be neat, legible, and simple. Avoid freehand lettering and heavy lettering and shading that could fill in when the figure is reduced. Consider column and page sizes when designing figures.

Finally

First-rate, professional papers are neat, accurate, and complete. Authors should proofread the manuscript for typographical errors and double-check its contents and appearance before submission. Mail the manuscript flat, first-class mail, to: Editor, *Marine Fisheries Review*, Scientific Publications Office, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., Bin C15700, Seattle, WA 98115.

The senior author will receive 50 reprints (no cover) of his paper free of charge and 50 free copies are supplied to his organization. Cost estimates for additional reprints can be supplied upon request.

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ISSN 0090-1830

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